

NOTES ON

POTTERY CLAYS

JAS. FAIRIE, F.G.S.

STOKE-ON-TRENT
PUBLIC LIBRARIES

**WITHDRAWN AND
SOLD BY
STOKE-ON-TRENT
CITY ARCHIVES**

Pottery Duplicate
Fairie

NOTES ON POTTERY CLAYS

THE DISTRIBUTION, PROPERTIES, USES,
AND ANALYSES OF BALL CLAYS,
CHINA CLAYS, AND CHINA STONE

BY

JAMES FAIRIE, F.G.S.

LONDON

SCOTT, GREENWOOD & SON

"THE POTTERY GAZETTE" OFFICES

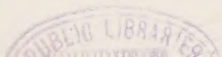
8 BROADWAY, LUDGATE HILL, E.C.

CANADA: THE COPP CLARK CO. LTD., TORONTO

UNITED STATES: D. VAN NOSTRAND CO., NEW YORK

1901

[All rights remain with Scott, Greenwood & Son]





CONTENTS

CHAP.	PAGE
I. CLAYS : DEFINITION—VARIETIES—PROPERTIES . . .	1
II. BRICK CLAYS—COMPOSITION AND PROPERTIES . . .	8
III. FIRE CLAYS—DISTRIBUTION, USES, AND ANALYSES . . .	15
IV. POTTERY CLAYS—PIPE CLAY	22
V. POTTERY CLAYS—BALL CLAYS—ANALYSES OF PIPE, BLACK, AND BROWN CLAYS	27
VI. ORIGIN AND COMPOSITION OF DORSETSHIRE AND DEVON- SHIRE CLAYS	36
VII. ORIGIN AND OCCURRENCE OF KAOLIN OR CHINA CLAY . . .	42
VIII. CORNISH CHINA CLAY—COMPOSITION AND ANALYSES . . .	50
IX. CORNISH CHINA CLAY	57
X. ANALYSES OF CHINA CLAY—METHODS OF OBTAINING AND PREPARING CORNISH CHINA CLAY	70
XI. CHINESE KAOLIN—HISTORY AND COMPOSITION . . .	87
XII. CHINESE KAOLIN—PETUNTZE	98
XIII. EUROPEAN AND CHINESE CLAYS COMPARED . . .	107
XIV. SOURCES OF IRISH PORCELAIN CLAYS	111
XV. IRISH CLAYS — ANALYSIS — COMPARISON WITH JAPANESE CLAYS	116
XVI. CHINA STONE : COMPOSITION—OCCURRENCE—ANALYSES . .	120
XVII. CHINA STONE—DISCOVERY AND USES	125
INDEX	131



Digitized by the Internet Archive
in 2025

https://archive.org/details/bwb_KV-429-596

NOTES ON POTTERY CLAYS



CLAYS

CHAPTER I

DEFINITION—VARIETIES—PROPERTIES

CLAY is an unctuous, tenacious earth, capable of being moulded by hand, and hardened by fire into permanent form. It is the Anglo-Saxon, *claeg*, derived from the Teutonic verb *kleven*, to stick or adhere, because of the clammy, adhesive quality of the substance, which is one occurring in more or less extensive deposits in almost every country of the world, and very abundantly, and in numerous varieties, in the British Isles. It belongs to the order of oxidised rocks, and forms the argillaceous (Latin, *argilla*—clay) family or group of rocks, and is a soft, opaque, amorphous earth of a dense texture, distinguished from every other by its great tenacity when moistened by water (a very remarkable illustration of which was furnished by the unfortunate results of the meeting of the Royal Agricultural Society at Kilburn in 1879), and, also, by its contraction under, and the great hardness which it acquires by, the action of fire; sufficient, indeed, to give off sparks when struck with a steel. Chemically speaking, clay is essentially a hydrated silicate of alumina; the latter being the oxide of the metal aluminium,

as silica is of the metalloid silicon; and these oxides being chemically combined with a certain proportion of water, which is a protoxide of hydrogen, it is obvious that oxygen must enter very largely into the composition of clay—to the extent, indeed, it has been calculated, of upwards of 48 per cent. of its weight.

Clay generally contains various impurities, of which oxide of iron is the chief, and generally also its colouring ingredient. To the presence of this oxide is due the peculiar smell given out by impure clays when breathed upon or wetted, and which is called the argillaceous odour; although it has been, and may be, ascribed also to their being impregnated with vegetable matter: alumina and silica and pure clay being all alike free of it. Common clays have an earthy texture with a dull lustreless fracture, and are soft enough generally to take a mark from the finger nail. H. 1·0 to 1·5; sp. gr. 1·8 to 2·7. Clays are never found crystallised; they are of various colours—brown, yellow, dull blue, green, red, grey, and white in the china clays.

There are perhaps no other substances in nature so indefinite in their composition as clays, which are all mechanical deposits, which, however consolidated, have not been subjected to any indurating or metamorphic action sufficient to alter their structure. They have all been derived from the disintegration and decomposition of rocks, chiefly granitic or felspathic, and necessarily, therefore, contain varying proportions of substances found in such rocks, as lime, potash, soda, magnesia, etc. They possess, from their alumina—a large percentage of which is an essential constituent of all clays—the property of absorbing and retaining, under less than a very high temperature, a considerable proportion of water, and of forming thereby a plastic paste of much tenacity, which is compact, smooth, and unctuous to the touch, and, when dry, easily polished by the finger or nail. Potters' and most of the other clays are infusible

under any degree of heat, but when they contain an excess of alkalies, these act as fluxes and produce vitrification, or even fusibility. They are not soluble in water, but mix readily with it; indeed, one of the characteristics of clay is its diffusibility in water, in which, although insoluble, it remains suspended longer than any other mineral substance—and part only at a great heat with the last portion of their hygroscopic water, that, namely, with which they are mechanically combined, while that with which their alumina and silica are chemically combined can only be driven off by a nearly red heat.

So numerous are the varieties of clays, that Brogniart, the late eminent director of the Sèvres Porcelain Manufactory, gives a list¹ with the analyses of no fewer than 195—of which 28 are china clays—all of which are made use of in various parts of the world; and Mr. George Maw, F.G.S., in his valuable catalogue of specimens illustrating the clays and plastic strata of Great Britain,² gives a list of 123, with descriptions and analyses of many of them. But whatever their composition, one essential property, which determines their being classed as belonging to the clay or argillaceous family, they all possess, viz. plasticity, although they may vary much in the degree in which they possess it.

This property of plasticity may be called peculiar to clay, which appears to be the only substance in the mineral kingdom that possesses it in its natural state. Tomlinson³ says: "The more I consider this property the more wonderful and inexplicable does it appear. Take a mass of dry clay; it cracks easily and crumbles readily; add to it a certain proportion of water,

¹ *Traité des Arts Céramique*, Paris, 1844, "Atlas of Plates."

² *Catalogue of Specimens in the Museum of Practical Geology, illustrative of the Composition and Manufacture of British Pottery and Porcelain*, London, 1876, 3rd ed., Appendix A.

³ "On the Plasticity and Odour of Clay," by C. Tomlinson, Esq., Lecturer on Science, King's College, London, *Proceedings of Geologists' Association*, vol. i.

and it becomes *plastic*—it obeys the will of the artist or the artisan, who can, out of this yielding mass, *create* new forms or perpetuate old ones. Drive off the water at a red heat, and its *plasticity* is for ever lost; *rigidity* takes its place; the clay is no longer clay, but something else. It may be reduced to powder, and ground up with water; but no art or science can again confer upon it its plasticity. All this is very wonderful. There is another fact that is equally so: if we combine the constituents of clay in the proportions indicated by the analysis of some pure type of that substance, we fail to produce plasticity." Tomlinson adds: "That a clear idea of plasticity, and of some of the other mechanical properties of matter may probably be gained by considering them due to variations of the forces of cohesion and adhesion, and by bringing those in their turn under Newton's great law of 'attraction—directly as the mass, and inversely as the squares of the distances';" and in illustrating this he suggests the idea, "that the mechanical properties of matter, such as porosity, tenacity, hardness, brittleness, elasticity, etc., depend upon variations in the attractive force of the molecules, according to the distances apart of such molecules"; and further states, that "the method of arranging the particles of clay, at the precise distance that shall impart plasticity, is one of nature's secrets that we have not yet succeeded in penetrating"; and to the questions—"Why is not a clay artificially formed from pure materials plastic?" or "why cannot we produce plasticity by the synthesis of clay?" the answer is, "that all the conditions of plasticity are unknown, and as yet it has proved beyond man's art or science to produce it." Clays, when dried in the air or not fired too hard, adhere to the tongue, in consequence of their affinity for moisture. Their affinity also for vegetable matter, bitumen, and some metallic oxides, particularly oxide of iron, and for acids and salts, make them very useful in many manufacturing processes.

Clays are either arenaceous (Latin, *arena*—sand) or calcareous (Latin, *calx*—lime), and there are various earths formed by admixtures of these, of which the following two are universally known, and need only be briefly mentioned here, viz.:—Loam, which is a general but not very definite term, applied to soils that are composed of clay, sand, and vegetable mould, is moderately cohesive, less tenacious than clay and more so than sand, permeable by water, with little or no plasticity, but more or less adhesive when wet, and more brittle when dry than clay. When united with lime, iron, or other metallic oxides, it is fusible at a high heat, and melts into a black, tough cinder. When common salt, saltpetre, phosphates, or sulphates are present it is still more fusible. Some of the more argillaceous loams are used for making the coarser kinds of potters' ware, and for tiles and bricks, and if any soluble salts are present in them these will appear as an efflorescence on the surface of the latter. Agriculturists speak of *light* and *heavy* loams, according to the proportion of clay they contain, and also of *sandy* and *calcareous* loams, according as sand or lime predominates in them. The other is Marl, which is a calcareous clay, that is clay mixed with lime, although clays which do not contain lime are often erroneously called marls. Any soft admixture of clay and lime is a marl; "clay-marl" when the clay predominates, "marl-clay" when the lime is most abundant. There are also "shell-marls," and, in geological nomenclature, "chalk-marls," "lias-marls," and others. A characteristic of a true marl is that when dry, it breaks into small cubical fragments and crumbles down, even to powder, by exposure to the atmosphere.

Shales and clay slates are also argillaceous rocks, and, like the clays, are impure silicates of alumina which have been deposited in marine or—often in the former, as in the case of coal shales—in brackish water, and subsequently indurated by heat and pressure. The former exhibit a laminated structure

and are fissile parallel with their bedding, while the latter are fissile in parallel planes *other than* those of their bedding. The difference between clays, marls, and shales is put thus by the late Professor Page: "Clays are massive or plastic, and void of structure; marls are friable or crumbly; shales always exhibit some degree of lamination and fissility, and, being in fact the solidified muds of former waters, they present endless varieties in composition, and are usually defined as calcareous, arenaceous, bituminous, and so forth, according to their predominating ingredients." The clay slates of metamorphosed clay occur in England, chiefly in the Cambrian formation, and are extensively worked in North Wales. They have been formed from the waste of pre-Cambrian rocks, deposited as fine mud or clay, in most cases, at the bottom of a deep sea, the fineness of the sediment forming them proving its having been carried in suspension in water for a considerable distance from land, while the great thickness of the beds proves that the process must have been carried on for an enormous period of time. In other cases, the mud has been deposited in deltas or at the bottom of lakes; and in these a larger amount of sand renders the texture of the plates coarser. After deposition and colouring by the admixture of the various oxides of iron and other colouring ingredients (such as carbon in the case of black slates) to which the various colours of slates—grey, dull blue, purple, green, and black—are due, the beds have been highly indurated and metamorphosed by heat, and vertical, combined with great lateral pressure, by which, with perhaps also some chemico-electrical action, their fissile structure and cleavage *across* the original lamination of their beds has been caused, and probably during the process of their upheaval, to form the mountain ranges of Wales and Cumberland and other places where they occur.

It may be interesting to give here an analysis of a good average quality of the roofing slates of Wales, showing that

their composition is a hydrated silicate of alumina—similar to the common clays—coloured by protoxide of iron. The percentage of oxygen in their various ingredients is also given.

WELSH ROOFING SLATE, sp. gr. = 2·824

Silica	60·50	Oxygen . .	32·27
Alumina	19·70	„ . .	9·19
Iron (protoxide).	7·80	„ . .	1·74
Lime	1·12	„ . .	0·32
Magnesia	2·20	„ . .	0·88
Potash	3·18	„ . .	0·54
Soda	2·20	„ . .	0·57
Water	3·30	„ . .	2·71
	100·00		48·22

Of the numerous varieties of clays the undernoted may be considered as coming within the scope of this work on potting materials; they being all extensively used in, and being in fact indispensable to, the prosecution of the potters' business; each of them having its own peculiar properties, and each being available for some special purpose in connection therewith, viz.:—

Brick Clays, used in the manufacture of flower-pots and other articles of common use, and for bricks for the workshops and kilns of the potteries.

Fire Clays, for the manufacture of terra-cotta ware, seggars, covers of slip-pans, where the latter has not been superseded by Needham & Kyte's apparatus, fire bricks for furnaces and flues, and the internal lining of stoves, muffles, and kilns.

CHAPTER II

BRICK CLAYS—COMPOSITION AND PROPERTIES

BRICK clays are impure hydrated silicates of alumina, and are chiefly superficial deposits, which are very widely distributed in beds covering extensive areas in nearly all parts of the United Kingdom; either as alluvial lake or river-valley deposits, or as estuary silts and marine beds. Brown loamy clays, which contain but a small percentage of argillaceous earth, are largely used for making common bricks, and are hence called brick-earths, but bricks are made of clays of very varied composition, according to the purposes for which they are required, or their occurrence in the localities where they are wanted. The most extensive deposits of brick clays are those practically inexhaustible beds of what is sometimes called "glacier detritus," the thick deposits of clays of the glacial or immediately post-glacial period. In geological classification the term brick-clay is often used in contra-distinction to that of boulder-clay; meaning by the former, those finely laminated clays of the Pleistocene epochs, which overlie the unlaminated beds of the true boulder-clay or till, and have evidently been formed from it by the wasting and re-assorting agency of water. Clays suitable for bricks, and other "clay wares," are, however, found to a greater or less extent in nearly all the various geological formations, from the older Palæozoic to the most recent; but increasingly indurated as they recede in time from the latter, until, as in the case of the clay slates, they have, through the pressure and metamorphic action to which they have been subjected, acquired a slaty structure, and have

entirely lost all plasticity. In various outcrops and beds of the tertiary and underlying formations down to the carboniferous, and occasionally even in older ones, clays of economic applicability (*vide* Mr. Maw's list) occur not merely in a soft and plastic state, but in every gradation between these and hard metamorphic rocks, and many of the most valuable clays occur in a semi-indurated condition, are mined by blasting, and brought to the surface in hard rock-like masses. However compact and hard such clays may have become, they are by "weathering" disintegrated and reduced, after being ground and mixed with water, to their original plastic condition. The durability of bricks and tiles is much increased by allowing the clay to lie mellowing for a year or two before it is used. Common brick clays consist generally of coarse and irregular mixtures of pure clay with sand, iron, calcareous and magnesian earths, mineral alkalies, carbonaceous matter, and various other accidental impurities; many of them, however, are of fine texture and comparative purity, but these are generally extremely local, and are used for special purposes. For brick-making, clays generally—especially when of stiff and dense texture like the London and the glacial clays—require considerable additions of coarse sharp sand and coal-breeze or ashes, which are indispensable for making good bricks; but the proportion of sand admits of great diversity, varying according to the relative proportions of the siliceous and aluminous constituents of the clays. Ansted says: "That the admixture of a percentage of silica sand, which results in a combination that contains as much as 90 per cent. of silica, is not at all incompatible with the formation of an excellent brick." It is the alumina, however, that renders them refractory, and not the silica, as is often erroneously supposed; for while *pure* silica, like alumina, can stand any amount of heat without fusing, its readiness to combine with the alkaline ingredients which all these clays contain to a greater or less extent—but which in good brick clays ought

not to exceed 2 per cent.—is very apt to result in vitrification or fusing of the bricks. Indeed, from over-firing and the presence of an excess of iron and alkaline earths or alkalis in the clay, bricks are frequently fused together or run into a mass of glassy slag, showing often a bright conchoidal (Gr. *konche*, a shell, and *eidos*, form) fracture. Iron, unless in excess, is not prejudicial, but when in excess, and lime is present, vitrification is apt to be produced, and the tendency to it is increased by the metallic alkalis in the clays. When clay contains too large a proportion of calcareous earth, lime will be produced by burning, and the bricks made from it will soon moulder when exposed to the atmosphere. The alumina of the clay does not melt, but its particles are cemented by the glassy products of the silica and fluxes; when it is in excess there will be a corresponding increase of shrinkage from its dehydration in firing; complete vitrification also produces great contraction in the bricks—most, however, with clays of fine texture, less, when they are coarse and containing a large proportion of sharp sand or other gritty ingredients. In firing, the shrinkage of brick clay may average about 10 per cent., but the degree of contraction is very various, and does not altogether depend upon the purity of the clay; when newly dug the contraction is less than it is when the clay has been well weathered. These clays vary in colour according to the character of the formations in which they occur, and the proportion of iron or other colouring ingredients they contain, and are found of all shades of brown, grey, or black, to yellow, blue, and red. They burn white when entirely free of iron, which, however, is rarely the case. When iron is present they burn to various shades of red—pale, dull, dark, or bright red—the depth of colour depending both on the percentage of iron present and the degree of heat to which they are subjected, the brightest shades of red and buff being produced with but a partial vitrification of the body; complete vitrification modifying the colours considerably. A

large proportion of carbonaceous matter affects the colour by arresting the peroxidation of the iron, as does also the alkalies, and still more so the alkaline earths, lime and magnesia. The clays coloured yellow by the hydrous sesquioxide of iron do not produce yellow or buff bricks, owing to being deprived in firing of their constituent water, to which that colour is due, and which is thereby changed to anhydrous red. Grey clays containing less than 1 or $1\frac{1}{2}$ per cent. of iron produce various shades of cream colour and buff bricks, while those containing from 2 to 10 or 12 per cent. of iron produce yellowish fawn to dark reds. Red clays containing from 3 to 4 per cent. of iron produce the bright red bodies used in the manufacture of red terra-cotta ware, encaustic tiles, etc.; but anyone interested in the composition of clays and their colouring ingredients may obtain further and much valuable information from Mr. Maw's list of the "Clay and Plastic Strata of Great Britain," previously referred to, and which the writer has drawn upon for some of the above details—especially those regarding the colouring ingredients of these clays.

Mr. Maw mentions having found by experiment that "five per cent. of caustic magnesia mixed with red clay entirely destroys its red colour in the kiln, probably from the production of a pale-coloured double silicate of iron and the alkaline earth; a familiar example of which reaction occurs in the process of manufacturing yellow bricks in the neighbourhood of London, the colour of which is dependent on the admixture of ground chalk with the brick-earth, which itself burns of a red colour."

Professor Donaldson states that clays containing silica and alumina in the relative proportions of eighty-six parts of the former to fourteen of the latter are the best for brick-making, but the under-noted analysis of four good brick clays shows that the composition of these admits of great variation; and, indeed, any approaching the above composition are of rare occurrence: a fourth of alumina to a half of silica in the clay, and with

small percentages of alkaline ingredients, is a good standard, to which No. 4 most nearly approximates.

	No. 1.	No. 2.
Silica and sand	64·14	61·09
Alumina	13·54	19·91
Oxide of iron	7·57	6·75
Lime	1·90	3·36
Alkalies	1·54	2·83
Water and various impurities	11·31	6·06
	100·00	100·00
	No. 3.	No. 4.
Silica and sand	66·16	53·95
Alumina	16·08	25·55
Oxide of iron	8·38	8·06
Lime	1·88	0·68
Alkalies	1·83	1·54
Water and various impurities	5·67	10·22
	100·00	100·00

Although bricks, when made, are generally well dried in the air before being placed in the clamp or kiln, they retain a large amount of moisture, and the first result of burning them is its evaporation, accompanied by that of carbonic acid, which imparts such a heavy and offensive quality to the fumes from brick burning, arising from the calcining of the lime in the clay and the combustion of the coal-breeze or ashes.

When thoroughly burned, the bricks or other "clay-wares" become permanently hard, and cannot by any possibility become again plastic or capable of being mixed with water; they are, however, porous, and readily absorb more or less moisture according to their composition, and the degree of heat to which they have been subjected in burning. Pulverised burnt bricks, and the burnt clay technically called "ballast," are good examples of unhydrated clay.

Clay, unmixed with siliceous ingredients, will not make durable bricks or vessels. The purer the clay, the more will it crack or split in drying; and deep clay soils will thus open in chasms of considerable width and depth; but with a proper admixture of siliceous materials, even when only hardened by the hot sun of tropical countries, clay vessels will retain their shape without cracking, and they, as well as similarly composed and sun-dried bricks, will resist for an enormous time, not merely atmospheric influences, but even the solvent power of water. Unless completely vitrified by burning, however, clay vessels cannot be made non-absorbent of moisture without a glaze of some sort, as witness the unglazed porous water-bottles so largely manufactured in England, and so universally made and used in Oriental countries, the coldness of the water in them being produced by its evaporation through the bottles and its condensation on the outsides. Vessels of pottery were probably made of clay, hardened by the sun, long anterior to the making of sun-dried bricks, and very early in the existence of at least the Adamic race of mankind; and such vessels are still made in the East. Sun-dried bricks were also, however, made in very early times, and the walls of houses were built of clay thus hardened—a reference to which is obviously made in what is probably the most ancient book extant—Job (*vide* ch. iv. 19), “How much less in them that dwell in houses of clay.” It is also evident from the fact of the Israelites, during their bondage in Egypt, using straw in brick-making, that the bricks they made for Pharaoh were only sun-hardened; that this was not from ignorance of the process of burning bricks, but, probably, to save the unnecessary cost of burning them, where in the hot and almost rainless climate of that country the sun-dried bricks were sufficiently durable, may be inferred from the fact that the Tower of Babel had been built upwards of 600 years previously, of fire-burned bricks (*vide* Genesis xi. 3, where the builders of that monument of man’s folly are represented as

saying, "Go to, let us make bricks, and burn them thoroughly"), and doubtless fire-burned pottery was also thus early made. From Job ch. ii. 8, "And he took him a *potsherd* to scrape himself withal," it may be inferred that in the early days in which Job lived it was not only made, but broken as well—a practice the continued prevalence of which is by no means of trifling importance to the interests of the pottery trade. It appears also from other ancient records, and from the numerous specimens dug from the ruins of Babylon and other long-destroyed cities of the East, that these clays were used very extensively from the most remote antiquity for an immense variety of articles—domestic vessels of all sorts, seals (mentioned also in Job, *vide* ch. xxxviii. 14, "As clay to the seal"), and cylinders, tablets, and bricks, on which records of events, royal mandates, contracts of sale, and other documents—the preservation of which was necessary—were inscribed, and remain perfectly legible to this day. Many of these may now be seen in the galleries of the British Museum: but although they remained in perfect preservation for thousands of years in the dry climate of the East, and not exposed to atmospheric action even there, owing to their being buried in the sand mounds, which for so long concealed the ruins of these ancient cities, it was found necessary to subject them to a baking process before transferring them to the moist climate of England, where otherwise they would soon have been destroyed.

CHAPTER III

FIRE CLAYS—DISTRIBUTION, USES, AND ANALYSES

FIRE clays are also hydrated silicates of alumina, generally freer of impurities than the ordinary brick clays, and are infusible compounds containing large proportions of silica, with but little iron or alkaline ingredients, and therefore capable of resisting very intense and long-continued heat without slagging, vitrifying, or melting, or becoming soft and pasty. Their refractory property is entirely due to the absence of fluxing matters—such as the alkalies, alkaline earths, and oxides of iron, with which the silica is so ready to combine—except in such minute quantities as not to induce vitrification or fusing in the process of burning the bricks or other fire-clay manufactures. Carbons and hydrocarbons are not unfrequently present in these clays, but the presence of carbonaceous matter (speedily consumed in the kilns) does not affect their refractoriness. Jukes says that in good fire clays “it is probable the silica and alumina exist in just that definite proportion which would form a true silicate of alumina.” Fire clays should be of somewhat greasy feel, and it is essential that they should be of uniform texture; they vary much in composition, but have been classed in three qualities, of which the first and purest is used chiefly for the large melting-pots for glass-making; the second, for crucibles used in melting metals and refining steel; and the third, for fire bricks and other ordinary fire-clay wares.

Fire clays are very abundant in the British Isles, and occur chiefly in the Coal Measures underlying the coal seams, owing

to which they are called the under-clay or seat-earth of the coal. The coal seams almost invariably rest on a comparatively pure argillaceous bed, and, from the amount of carbonaceous matter it contains, and the abundance in it of the rootlets (*stigmaria*) of the *Sigillaria*, it has doubtless formed the soil in which these and other coal plants grew. In the Dudley coalfield, beneath the ten-yard coal seam and some underlying layers of mixed matter, the fire clay is found of considerable thickness, varying much in quality, the best being found near Stourbridge, 7 or 8 fathoms under the main coal, and is remarkable for its small amount of contraction in firing. When first raised this Stourbridge fire clay is of almost stony hardness and a leaden or slaty-grey colour; it soon however crumbles on exposure to the air, and is then easily softened and tempered with water; it burns to a yellow or ochreous tint. The strata in the neighbourhood of Stourbridge are extremely faulted and shattered, and although lying low in the order of stratification, the fire-clay seams have been upheaved, so as in many places to be got at without very deep sinking. In other places, and in many coal-fields, they occur lower and at great depths, and can only be profitably utilised when raised along with the coal or ironstone with which they are found associated. The Stourbridge clays are raised from seams in the pits varying from 20 to 95 fathoms deep, and averaging about 3 feet in thickness; and, as evidence of the extremes of quality, it may be mentioned that while the ordinary quality is sold for 15s. per ton at the pit mouth, that for crucible making, found in the middle of the seams—known as glasshouse pot clay—sells at 60s. From the analyses, by Prof. F. A. Abel, F.R.S., chemist to the War Office, quoted by Dr. Percy, of nine samples from different pits, the composition of these clays varies as follows, viz.:—Silica, from 58·48 to 67·00 per cent.; alumina, 25·80 to 35·78; iron oxide, 3·00 to 6·63; alkaline matter and waste, 0·64 to 3·56

per cent. ; and the undernoted two may be taken as of superior quality, viz. :—The first—

Silica	63·40	In this case the clay had been deprived of its water before the analysis was made.
Alumina	31·70	
Iron oxide	3·00	
Alkaline earths and waste	1·90	
	—————	
	100·00	

The next is one made by Mr. C. Tookey, in the metallurgical laboratory of the Museum of Practical Geology, under direction of Dr. Percy, and quoted in the *Catalogue of British Pottery and Porcelain* :—

Silica	65·10
Alumina	22·22
Proto-oxide of iron	1·92
Lime	0·14
Magnesia	0·18
Potash	0·18
Phosphoric acid	0·06
Organic matter	0·58
Water, combined	7·10
„ hygroscopic	2·18
	—————
	99·66

The refractory property of these, or any clay, is least affected by magnesia, more so by lime, still more so by iron oxides, and most of all by potash, while an excess of sand is most prejudicial to plasticity.

Fire clays are very abundant in the Coal Measures of Durham and Northumberland, and are found in seams from 1 to 5 or 6 feet in thickness ; the best qualities are obtained from those underlying the coal used for coking and manufacturing purposes. The undernoted analyses are from samples taken

from mines a few miles west of Newcastle, belonging to one firm, and show wide ranges of variation :—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
Silica	51·10	47·55	48·55	51·11	71·28	83·29	69·25
Alumina	31·35	29·50	30·25	30·40	17·75	8·10	17·90
Iron oxides	4·63	9·13	4·06	4·91	2·43	1·88	2·97
Lime	1·46	1·34	1·66	1·76	} 2·30	2·99	1·30
Magnesia	1·54	0·71	1·91	trace			
Water, organ. matter, and waste }	9·92	11·77	13·57	11·82	6·24	3·74	8·58
	100·00	100·00	100·00	100·00	100·00	100·00	100·00

Of these Nos. 1 to 4 will be found, from their large proportions of alumina and water, to shrink more than the others, of which No. 6 will contract least in firing.

Fire-clay goods are used now so very extensively, and for so many purposes, that the possession of such a series of beds as the above, which the Newcastle Coal Measures yield, gives great advantages to manufacturers, enabling them to select and mix their clays so as best to adapt them for specific uses; and the circumstance of these clays being found in great abundance and capable of being more economically worked and manufactured on Tyneside than, perhaps, in any other part of the United Kingdom or of Europe, may account for the extensive business now done there in fire-clay goods, from bricks to gas retorts, and of articles both numerous and of great variety for building and manufacturing, sanitary, and ornamental purposes. The great heat required to vitrify drainage pipes insures their being thoroughly burnt, and enables them more efficiently to resist corroding and chemical action. Some of these have been tested to sustain a pressure of from 80 to 120 lb. on the square inch, and when well burnt and glazed they are practically imperishable. Samples from Glasgow, Dowlais, Cool Island, Stanington, and Howth show the undernoted maximum

and minimum percentages of the principal ingredients :—Silica, from 43·00 to 67·96 ; alumina, 21·18 to 40·09 ; iron oxide, 1·19 to 8·4 ; water and various matters, 3·14 to 15·10 per cent. The Glasgow (Garnkirk) fire clay is of very superior quality, as may be seen from the following analyses of two samples :—

Silica, 66·68 ; alumina, 26·08 ; lime, 0·84 ; iron oxide, 1·26 ; water, 5·14 = 100·00. Silica, 65·20 ; alumina, 33·41 ; lime, 0·32 ; magnesia, 0·13 ; iron oxide, 0·49 ; phosphates, 0·45 = 100·00. Specific gravity, 2·358.

A variety of fire clay occurs at Dinas in the Valley of Neath, Glamorganshire, which consists of nearly pure silica, and which Dr. Siemens states he has found to be the only material practically available on a large scale for bricks or furnace lining, to resist the extreme heat (4000° Fahr.) for melting steel. The celebrated Dinas fire bricks possess the peculiar property (as compared with other clay wares) of expanding instead of contracting under heat, which renders them more suitable for some special purposes than any other.

In Staffordshire there is an abundance of fire clays in the Coal Measures, which are locally called marls, and are extensively used for making the seggars in which the pottery wares are fired. The marl is mixed with old ground seggars, and stands very well the heat of the biscuit kilns in firing ordinary earthenware, but it is inferior to the fire clays used by French porcelain manufacturers, and would not be sufficiently refractory for firing the superior hard porcelain wares now made in Staffordshire, but for the fact that oxidising firing is employed, whereas, on the continent, the firing must be reductive. The Nungarrow porcelain made in Wales some sixty or seventy years ago—specimens of which from their superior quality now command high prices—was made of a most refractory body, and required the sacrifice of the seggars in which it was fired, as, owing to the extreme heat necessary for its conversion, they were useless for a second firing. The

CHAPTER IV

POTTERY CLAYS—PIPE CLAY

OF pottery clays—so called because suitable for the manufacture of pottery wares—the distribution is very wide and the origin very various. They are embraced in the French term *figuline* (Lat., *figulus*, a potter, from *figo*, to fashion). The purest varieties are white or light-bluish grey, are very plastic, and are chiefly found in the superior beds of the more recent geological formations. The Eocene clays of the Paris basin, which immediately underlie the Eocene clay of the London basin, so well known as the “London Clay,” received the name of *argile plastique* originally in France, says Lyell, from its being much used there for pottery wares. Beds of the same age (the Woolwich and Reading series of Prestwich) are largely used for the same purpose in England. “As a series,” says Page, “these plastic clays constitute the middle portion of the Eocene group. They are partly of marine and partly of fresh-water formation, and are characterised by two species of oyster (*Ostrea bellocacina* and *O. edulina*), and some fresh-water shells, as *Melania*, *Cyrena*, *Unio*, *paludina*, etc.” These clays, like those more common and impure varieties already described (*vide* Chaps. I. and II.), are all more or less pure hydrated silicates of alumina. They are found very generally all over the world, and very abundantly in many districts of England and Wales, and of Scotland. They occur also in Ireland—a country rich in mineral deposits of every sort, and in the raw materials for mining and manufacturing industries, and which only awaits the development of these to become

a perfect hive of busy labour, and the seat of wealth-producing arts and manufactures—although from the unhappy causes which conduce so effectually to prevent the investment of capital, and the suppression of industrial enterprise there, its rich deposits of mineral wealth still lie neglected and unworked.

These clays occur of very varying composition, quality, and colour, the latter ranging from white, yellowish-white, and greys of various tints, to brown, yellow, green, red, and black. With the exception of the last—which is due to the presence of organic, carbonaceous, or bituminous matter, and is in most cases burned out of the clay in firing, leaving the biscuit ware perfectly white—these colours are chiefly derived from various oxides of iron, or, in the case of brown clays, from manganese. They all possess the qualities already mentioned as characterising the argillaceous family of rocks; adhere strongly to the tongue; contract to a greater or less degree in the kiln—often with much irregularity; are more soft, soapy, and plastic than brick clays; and are all, when free from excess of iron, alkalies, or other fluxing ingredients, perfectly infusible, by which is meant that they will not melt or become pasty in the most intense heat of the biscuit kiln, or say 3272° F.—about the melting-point of wrought iron. “All clay at a sufficient heat,” says Janvier, “would melt into a sort of glassy substance.” That, however, is not so. Perfectly pure clay is practically infusible under any heat; such a clay, however, is of very rare occurrence, and in pottery clays there may be found many varying much in refractoriness according to their contained proportions of silica and fluxing ingredients. Most of them contain larger or smaller percentages of such ingredients, as felspar, iron, lime, magnesia, manganese, mica, potash, soda, and free silica, quartz, or sand. The more alumina a clay contains, and the purer it is, the greater is its refractoriness. With the exception of those containing iron, pottery clays generally burn white in the kiln.

Of the finer kinds of these plastic clays there are numerous varieties, some only suitable for coarse pottery and terra-cotta ware; others for the finer kinds of brown and red ware and tiles; and others again for the best qualities of common earthenware, which embrace the excellent brown and blue ball clays of Dorsetshire, and the black and cracking clays of Devonshire; all of which will be noticed more in detail in these pages.

Of these clays the purest are the well-known pipe clay (so called from its extensive use for the manufacture of tobacco pipes) and china clay or *kaolin*, which will be described in subsequent chapters. The latter of these is generally believed to be derived from the decomposition of the potash felspar (*ortho clase*) in certain kinds of granite, and is at all events only found in the granite districts, chiefly of Cornwall, while pipe clay, which has been called plastic clay, *par excellence*, occurs in extensive deposits in the Miocene and Lower Tertiary beds of Devonshire and Dorsetshire, whence it is largely shipped to the potteries for home manufactures, besides being extensively exported to France, Belgium, Holland, and elsewhere. The composition of pipe clay resembles that of china clay, but it contains an excess of silica. It may be stated as silica 54, alumina 32, water 12, with small quantities of lime and magnesia, etc. It is remarkably free generally from iron; is compact, unctuous, and almost greasy to the touch, and is very pure, plastic, and infusible; when dry, may be polished by the finger. While exceedingly plastic it yet forms a very tenacious paste, and is very absorbent of moisture, and consequently adheres so strongly to the lips, that the ends of the tobacco pipe stems require to be glazed ere they are fit for use. It burns very white, and the best qualities when fired are entirely free of the yellow or brown spots, which, in the biscuit of so many pottery clays, indicates the presence of iron.

This clay is applied to many purposes besides the making

of pipes, but contracts too much in firing to be available for general pottery purposes, although it is occasionally used for mixing with other clays for some wares. The best qualities are got at Bovey Tracey, in Devonshire, and in the Island of Purbeck, in Dorsetshire. There are two varieties of the Dorsetshire pipe clays, of which one is much darker than the other. Their composition is as follows, both having been first deprived of their hygroscopic water, viz. :—

	Light variety.	Dark variety.
Silica	65·49	72·23
Alumina	21·28	23·25
Oxide of iron	1·26	2·54
Alkaline earths	7·25	1·78
Sulp. of lime	4·72	trace
	100·00	99·80

Ansted gives the following analysis of another variety, viz. :—

Silica	53·66
Alumina	32·00
Iron oxide	1·35
Lime	0·40
Magnesia	trace
Water	12·08
	99·49

Pipe clays are largely used for cleaning and whitening the gloves and leather belts of soldiers, and the common kinds are much used for household purposes, pipe-claying stone steps, window-sills, etc. The finest quality is used for the manufacture of the Cologne pipes.

Pipe clay is found in Ireland, associated with lignite, in the beds of the Lough Neagh series. It lies in a hollow in the carboniferous limestone at Loughloheny and Ballymacadam, south-east of Cahir; and three miles north of Cahir similar

clay occurs. These are the remains of a once extensive deposit. Below the lignite beds, this clay is perfectly pure, and has been largely exported to England for the manufacture of the finer kinds of pottery. There are also deposits of pipe clay in Arran island, Co. Donegal, along the shore of Lough Ree, Co. of Roscommon, and especially near St. John's Point, where it is locally largely manufactured into tobacco pipes. Pipe clay also occurs near Blackball, north of Brosna, King's Co., and, in addition to its use for tobacco pipes, it was used by the late Earl of Rosse for lining his furnaces. In an extensive district of Tipperary, between Cahir and Clonmel, there are deposits of pipe clay in the cavities of the lower limestone, which are considered equal in quality to the pipe clay of Bovey Tracey. It burns purely white, and large quantities of it have been exported to England.

CHAPTER V

POTTERY CLAYS—BALL CLAYS—ANALYSES OF PIPE, BLACK, AND BROWN CLAYS

THE varieties of pottery clays are so numerous that anything like an exhaustive list and description of them would far exceed the necessarily limited space available. Those of our readers, however, who may be interested in ascertaining whether any of the native clays, not hitherto much utilised, can be profitably made available for potting or other purposes, will do well to consult Mr. Maw's *Catalogue of the Clay and Plastic Strata of Great Britain*, already referred to and quoted. In that catalogue Mr. Maw gives a list of 123 varieties of pottery clays—ranging from recent alluvial and post-tertiary deposits through all the geological formations down to the Silurian. These clays are of many sorts and of various origin, and differ from each other in composition and purity, in colour, in plasticity, and tenacity, in their degree of contraction in the kiln, and in their refractory qualities. Some of them have already been referred to and described in preceding chapters; in this, attention will be chiefly confined to the ball clays of the Miocene lignite beds of Bovey Tracey, Devonshire—of fresh-water lake formation—and those of Poole, which are found in the Lower Bagshot beds, of middle Eocene age, and which are of marine origin, except the fresh-water deposits in the Island of Purbeck. The Poole clays—so called from their being shipped at that port—form very extensive beds in the neighbourhood of Wareham, Dorsetshire.

The Bovey Tracey beds are of uncertain thickness, and

have been estimated to range from 200 to 300 feet in depth. One section, given by Woodward in his *Geology of England*, shows various seams of clays, sands, and lignite, of about 110 feet in all, under the surface drift, and resting on sand—the clay seams being together about 40 feet in thickness. Dr. Miller, in vol. li. of the *Philosophical Transactions*, describes the whole series of strata as dipping to the south about 20 inches in a fathom, and says that including the beds of clay with which they are intermixed—there being about six beds of each—the thickness of the whole is about 70 feet. These clays are very varied in their composition and qualities, and are probably derived from the waste of the neighbouring green-sand formation, and of the granitic rocks of Dartmoor, or, as Mr. Maw suggests, partly from the insoluble matter in the chalk. They consist of some valuable beds of white pipe clay, and of good pottery clays, grey, blue, brown or chocolate-coloured, and black; also that known as cracking clay, from its tendency to crack in firing. The clays are dug from pits, in balls of about 30 lb. weight, at Teigngrace and Whiteway, near Kingsteignton and Newton Abbot, and are shipped from Teignmouth, and thence sometimes called “Teignmouth clays.” Mr. Maw¹ quotes Mr. Charles D. Blake, of Newton Abbot, as stating that “the mines there produce clays containing silica and alumina in every proportion, from 95 to 50 per cent. of silica and from 50 to 4 per cent. of alumina”; also “that some of them are nearly pure silicates of alumina, containing no free silica, whereas others contain as much as 70 per cent. of it.”

The Lower Bagshot beds of Dorsetshire consist of alternating seams of variously-coloured potting clays and pale yellow or buff-coloured siliceous sands and loams and beds of flint pebbles;

¹ In a Paper on “The Sources of the Materials composing the White Clays of the Lower Tertiaries,” *Quarterly Journal Geological Society*, vol. xxiii. pp. 387 to 394.

beneath the potting clay there is a seam of some thickness of an extremely friable earthy brown coal, somewhat analogous to that of the Bovey lignite, but of less specific gravity. It is interesting to note the occurrence of this, characteristic, as this brown coal or lignite is, of the plastic clay tertiary deposits of the Isle of Wight and the London and Paris basin and others. On the north side of the chalk hills, extending from Handfast Point to beyond Corfe Castle, there is an extensive bed of pipe clay in a horizontal position, which has been identified with the lignite clay bed of Alum Bay, in the Isle of Wight. The same seam of clay, though not of equal quality, may be traced in the hills near Poole, and is found in many parts of the extensive track called the "trough of Poole." In a quarry on the borders of Poole Harbour, about 2 miles west of Poole, several beds of the white pipe clay from 3 to 5 feet thick occur, alternating with beds of brown clay, and white, red, and black sand. The Poole ball clays are extensively used for pottery, and are found in beds of various thicknesses and at different depths. They are dug to a great extent, at Creech Grange, Nordon, and Rempstone, between Wareham and Corfe. They are of very superior quality, and consist of white pipe clay and grey, blue, and brown pottery clays. The blue clay contains a little more alumina than that of Devonshire, and is so far superior to it for earthenware manufacture, although in practice the difference is not always perceptible. Other ingredients being equal, the excellence of pottery clays may be determined by the respective percentages of alumina which they contain. Alumina is a light material, while silica is a heavy one, and the specific gravities of these clays may therefore afford an approximate test of their value for earthenware manufacturers. Both the Teignmouth and the Poole clays are remarkably good and plastic and of excellent working quality, and from their comparative freedom from iron and alkalies they are valuable, owing to

their refractoriness and their great whiteness when fired. Their specific gravities may be taken as ranging from 1·725 to 2·250. While the better qualities are much used for earthenware and stoneware manufacturers, others are very suitable for flooring tiles, drain-pipes, and other pottery wares.

These clays generally appear to be derived from the disintegration of other rocks, and the natural separation of their constituent materials by the aid of water and atmospheric influences, which have resulted in local deposits of them—as in the case of steam ore and china clay—which in some places are coarse and impure, in others finer and more or less free of impurities. Some of them are much in request by sculptors and modellers.

In the clays derived from the decomposition of felspars, there is always to be found a considerable quantity of free silica in the form of quartz sand.

The whitest clays are esteemed the purest, but Dr. R. Watson, in his valuable chemical essays,¹ a work which has been highly recommended by Dr. Percy, in his popular lectures on metallurgy in Jermyn Street Museum, states (vol. ii. p. 256) that “I took 16 oz. of the finest pipe clay from Dorsetshire, and by repeatedly washing it in large quantities of water and pouring off the turbid water, I collected a sandy sediment, amounting, when well dried, to 3 oz. I have no doubt that this clay contained a much greater proportion of sand than what I had been able to collect; for the white particles which had been suspended in the water certainly consisted in part of a sand of a finer grain than what had settled to the bottom, for they were sensibly gritty between the teeth. It may easily be conceived that, in washing clays, the finest part of the sand (silica) contained in them will remain suspended in the water, and that, on this account, the sediment collected at the bottom

¹ *Chemical Essays*, by R. Watson, D.D., F.R.S., 6 vols. London: Evans, 1793.

of the vessel in which the operation is performed, will not give the true proportion of the sand which enters into their composition. In confirmation of this, we have been instructed, by the experiments of a very able chemist, to consider these fine white clays as consisting of about three parts in eight of true argillaceous earth, and of about five parts in eight of sand, or earth resembling powdered flints.

In contrast to the above, Mr. Maw, in the paper above referred to, states, that "in testing the peculiarly fine state of subdivision of the white tertiary clays of the Bovey Tracey and Wareham beds, I found that, after mixing them with water to the consistency of cream, and passing them through fine silk lawn, containing 10,000 perforations to the square inch, no appreciable quantity of coarse matter remained behind from most of the examples, not even to the weight of a grain out of several pounds of clay," and he adds, "I can state, from the result of a number of experiments on clays and marls of various ages and formations, that such a state of subdivision is peculiar to these tertiary clays."

From these so opposite results, from two competent practical observers, it is evident that all these clays cannot be referred to a similar origin. Mr. Prestwich and many other geologists consider these clay deposits to be derived from the denudation from old crystalline and granitic rocks; Mr. Green, in his book on Geology, says, "from the decomposition of felspathic rocks by carbonated water." Messrs. Pengelly & Heer, at p. 9 of their memoir, "On the Lignite Formation of Bovey Tracey," published in the *Philosophical Transactions*, make reference to "the probable derivation of the deposit from the degradation of the Dartmoor granite"; but Mr. Maw, in quoting their opinion, says that "this inference seems to be due more to the geographical proximity of the granite to the clays of the lignite formation than to any more certain evidence"; and further that "the occurrence of beds of similar physical character and age,

Total soluble in hydrochloric acid. 27·96

Insoluble in hydrochloric acid :—

Alumina	18·87
Lime	0·25
Magnesia	0·18
Silica	51·88
Alkalies and loss.	0·86
	72·04
	100·00

These clays are often of grey or blue colour before exposure to the air, but when so exposed become, from further oxidation, more or less yellow or red.

The following is an analysis of a yellow clay used for coarse ware :—

Silica	58·07
Alumina	27·38
Iron oxide	3·30
Lime	·50
Magnesia	trace
Water, etc.	10·30
	99·55

Black Clay owes its distinctive colour to the quantity of carbonaceous or bituminous matter which it contains; one variety of it, containing 13 per cent. of carbon, burns extremely white, which is caused, Mr. Maw states, “by the reduction of its sesquioxide of iron in the kiln by reaction with its carbonaceous matter.” In all these clays the black colouring matter is entirely consumed and dissipated in firing, leaving the biscuit ware of a very good white, and which, indeed, is said to be the whiter in proportion as the clay has originally been blacker. The analysis of a variety of this dark-coloured clay was given in a former chapter as: silica, 72·23; alumina,

23·25 ; oxide of iron, 2·54 ; alkalies and alkaline earths, 1·78 ; loss 0·20 = 100·00. This was an analysis by Prof. Way of a black pipe clay from the Lower Bagshot deposits in the Island of Branksea, Dorsetshire.

Cracking Clay is so called from the tendency it possesses of causing the ware to crack in the biscuit firing. This tendency to cracking may, to a great extent, be corrected by a judicious admixture of other clays and flint, but probably the clay would be little used in potting, owing to the trouble and uncertainty this occasions, were it not for the fact that it produces a biscuit ware of extreme whiteness.

Brown Clay owes its colour to manganese probably. It produces a white biscuit ware, but this has such a tendency to imbibe moisture, that many potters refuse to use this clay at all. The moisture which it imbibes in the biscuit state is parted with only in the glost kiln, and its escape there causes the glaze to craze much. This clay besides will not bear exposure to any great amount of heat, and it is therefore generally only used for black and common red wares.

The following are the analyses of two varieties of it, the first of which is from Dorsetshire :—

Silica	.	.	.	.	63·00	.	.	.	.	49·44
Alumina	.	.	.	.	32·00	.	.	.	.	34·26
Oxide of iron	.	.	.	.	3·00	.	.	.	.	7·74
Lime	.	.	.	.	—	.	.	.	.	1·48
Magnesia.	.	.	.	.	1·00	.	.	.	.	1·94
Water and Loss	.	.	.	.	1·00	.	.	.	.	5·14
					100·00					100·00

Blue Clay is decidedly the best of all the ball clays. That from Dorsetshire is preferred to the Devonshire for earthenware

and stoneware manufacture, and commands a higher price in the potteries, which may on an average be about an eighth more than the price of the latter. This clay combines the greatest number of good qualities. It produces a very white and solid body of ware. It is capable of being advantageously mixed with a greater percentage of flint than any of the other ball clays or china clay. This not only increases the whiteness of the ware, but produces a better body, and counteracts also, to a great extent, the tendency of the clays which have an excess of alumina in their composition, to shrink too much and crack. Its colour has been attributed to its being derived from the decomposition of the felspar of syenite, a variety of granite in which mica is replaced by hornblende; but if its origin can be proved to be from chalk, its colour must then be attributed to a protoxide of iron. Mr. Maw gives the composition of the Poole clay, so extensively used in the potteries, as silica about 60 per cent., alumina about 34, potash 2, oxide of iron and water about 4 = 100·00.

CHAPTER VI

ORIGIN AND COMPOSITION OF DORSETSHIRE AND DEVONSHIRE CLAYS

IN the previous chapter a quotation is given (p. 28) from Mr. Maw's paper in the *Quarterly Journal of the Geological Society*, in which he quotes Mr. Charles D. Blake, of Newton Abbot, as stating that "the mines there produce clays containing silica and alumina in every proportion, from 95 to 50 per cent. of the former, and from 50 to 4 per cent. of the latter." Now, by referring to the first of these articles on clays, it will be seen that clays are essentially hydrated silicates of alumina—that is, they are composed, when pure, of a chemical combination of silica, alumina, and water—the alumina having the property of absorbing and retaining, under less than a very high temperature, a considerable proportion of constituent water, to which the plasticity of the clay is due. Clays rich in alumina, known as "fat," are thus more liable to cracking and shrinkage than poorer or "meagre" clays; but this tendency is corrected by the presence of a due proportion of silica, clays deficient in the latter requiring, of course, a larger proportion of ground flint mixed with them in the slip to produce a good sound biscuit body. Besides their constituent or chemically combined water, clays are found often containing greater or less percentages of moisture, which is called their hygroscopic water, and which they part with in drying, or at a low heat, while it requires a red heat to deprive them of the former. Now it is evident that any substance

containing 95 per cent. of silica, and, say, 4 per cent. of alumina (which is the minimum percentage found in the Newton Abbot mines referred to), could only—supposing them perfectly pure, and thus free of all impurities, such as iron, lime, magnesia, etc., and also quite dry or free of all moisture—have 1 per cent. of constituent water ($95 + 4 + 1 = 100$). As none, however, of these clays are found absolutely pure, but on the contrary have at least from 2 to 4 per cent. of impurities, there cannot be in this case sufficient water to impart plasticity and to constitute clay. It is therefore probable that as the disintegrated material of the rocks from which the deposits in these mines have been derived—whether from the decomposition and waste of the Dartmoor granites or otherwise—have been deposited, owing to the different specific gravities of the silica and alumina, in various beds differing widely in their respective proportions of these materials, that those referred to by Mr. Blake are really deposits of silica, mixed with 5 per cent. of alumina, and iron, lime, or other impurities.

Mr. F. W. Rudley, of the Museum of Practical Geology, in his remarks on the origin and composition of clays (*Catalogue of Specimens*, p. 4), says, that “when the remains of the decomposed felspars are washed into localities where they become mingled with other earthy matters in a finely comminuted state, or when they have been derived from a rock which contains decomposing hornblende, the resulting material is no longer white, but is variously coloured. Even when we suppose the purer varieties to have been deposited in the first instance, and to have formed distinct beds—as, for example, the clays of Bovey Heathfield, in Devonshire, which appear to have been washed, with other detrital matter, and even trees, from the granitic region of a part of Dartmoor in previous geological times—it is easy to see that these clays may be again removed by atmospheric influences, rivers, and other abrading

agents, and thus be rendered impure by the admixture of a variety of substances brought into intimate association with them by these causes."

In this way beds of re-deposited clays of very varying composition may occur, more or less widely dispersed, and of varying thickness.

In reference to the Teignmouth clays, De la Beche says:¹—"These clays" (which he calls supra-cretaceous or tertiary, they having not, when he wrote, been ascertained to be of Miocene Age) "are stated to have been first worked about the year 1730, and would appear to have been formed naturally, much in the same manner as is now done artificially in Cornwall and Devon, though on a larger scale; decomposed granite having been washed down from Dartmoor into a lake or estuary, so that while the grosser particles were first lodged at its higher end, nearest the granite, the fine sediment was accumulated at the lower part."

The Poole clays, Mr. Rudley states (p. 5), "are examples of tolerably pure clays (that is, containing a large proportion of silicate of alumina, with free silica, but without injurious ingredients) which have been accumulated far from any decomposing crystalline rocks, such as granites, porphyries, and the like. . . . Its decomposed felspathic matter, affording the silicate of alumina, and a portion at least of the free silica, may readily have been derived from other beds, such as those of many sandstones, in which that matter may have been disseminated. Prior existing clays may also have been broken up and re-deposited."

As sandstones seldom contain much felspathic ingredients, other than the siliceous, it is more probable that the Poole clays have been derived from the waste of clay slate rocks—an opinion held by Mr. Robert Hunt, F.R.S., of the *Mining Record*

¹ *Report on the Geology of Cornwall, Devon, and West Somerset*, by Sir H. T. de la Beche, F.R.S., 8vo, 1839.

office. These clays appear to have been worked at an earlier date than the Teignmouth clays—at all events they are referred to in an “Order of Council,” in 1666, which directs that no dues were to be paid on tobacco-pipe clays; by which name the Poole clays are designated in an Act of Parliament, obtained by Poole, in 1756. Mr. Rudley gives an extract from Hutching’s *History of Dorsetshire*, published in 1774—for which he acknowledges himself indebted to Mr. William Joseph Pike, of Wareham—in which it is stated that these clays are the chief exports from the “Key of Wareham”; and from the edition of that work published in 1796, he quotes that “good tobacco pipe clay is dug round this town (Wareham) at Arne Hill, Heneger Hill, Norden, etc. It formerly sold at 50s. a ton, but now (1796) at 14s. or 15s. Nearly 10,000 tons are annually exported to London, Hull, Liverpool, Glasgow, etc., but the most considerable part to Liverpool (Runcorn), for the supply of the Staffordshire potteries, and to Selby for the use of the Leeds potteries. The principal pits are on Norden and Witch farms, the former belonging to William Moreton Pitt, Esq., and the latter to John Calcraft, Esq., and the clay taken from the same is in great repute with the Staffordshire and Yorkshire potteries from its peculiar excellence, and being the principal ingredient in the ware commonly called Staffordshire ware, so universally in use in this Kingdom, as well as in many parts of Europe.” In 1874 the production of Poole clays was 79,205 tons, and of Teignmouth clays 59,789 tons. The production in 1882 will be given at the close of these papers. Bristow states that much of the Dorsetshire pipe clays, which are not of sufficiently good quality for use in the potteries, is converted into alum by treatment with sulphuric acid. In his paper on the white clays of the Lower Tertiaries already referred to, Mr. Maw gives the under-noted analyses of the clays of the Bovey Tracey lignite deposits, No. 1, being a china ball (or pipe) clay, and No. 2, a blue ball clay from Newton

Abbot; he also gives, No. 3, an analysis of blue ball clay from Wareham.

	No. 1.	No. 2.	No. 3.
Silica	67·50	47·00	60·00
Alumina	29·00	48·00	34·00
Oxide of iron	1·00	1·50	2·50
Magnesia	1·50	2·00	—
Potash	—	—	2·00
Water and waste	1·00	1·50	1·50
	100·00	100·00	100·00

Mr. Rudley gives the undernoted as the relative composition of the ball clays of Devon and Dorset respectively, from analyses made in the Laboratory of the Museum of Practical Geology, by Mr. W. Weston, viz.:—

Bovey or Teignmouth Clay, a natural Kaolin from Bovey Heathfield, Devonshire.

Silica	52·06
Alumina	29·38
Potash	2·29
Lime	0·43
Magnesia	0·02
Protoxide of iron	2·37
Water, combined	10·27
„ hygroscopic	2·56
	99·38

Poole, or Blue Clay, from Wareham, Dorsetshire.

Silica	48·99
Alumina	32·11
Potash	3·31
Lime	0·43
Magnesia	0·22
Protoxide of iron	2·34
Water, combined	9·63
„ hygroscopic	2·33
	99·36

Ansted¹ gives the following analysis as that of the best blue clay—such as occurs in the Wareham beds, viz.:—

Silica	46·38
Alumina	38·04
Iron oxide	1·04
Lime	1·20
Magnesia	trace
Water	13·57
	100·23

In the Island of Purbeck there are deposits of clay of such a variety of composition, that they may be found there suitable for every purpose, except those for which kaolin, or the best china clays, are required.

¹ *Lectures on Practical Geology*, by Professor J. T. Ansted, M.A., F.R.S., London, 1865.

CHAPTER VII

ORIGIN AND OCCURRENCE OF KAOLIN OR CHINA CLAY

HAVING now given a brief account of those pottery clays, so called, chiefly used in the manufacture of earthenware, it may be interesting to refer shortly to a noticeable difference in at least the mode of occurrence, if not in the origin as well, of these clays from that of kaolin, or china clay proper.

The former may be called *natural* products in contradistinction to the latter, which are so far *artificial* that, with a few exceptions—which are sufficient to show, however, that the difference between them is more accidental than essential—they do not occur as deposits fit for use without certain processes of preparation, which are not necessary in the case of the former.

The pottery clays, whatever their origin, have been separated from the rocks from which they are derived by the disintegration of the latter by natural agencies, chemical and atmospheric, and except in such cases as those referred to by Mr. Maw, in which they are found in hollows of the chalk or limestone rocks, from which they have probably, as he believes, been derived, have afterwards by rains or streams been gradually washed down, during long periods of time, into lakes or estuaries, until they formed thick beds, such as those of Bovey Tracey, Wareham, Purbeck Island, and other localities.

In the transport, by the agency of running water, of the materials separated by the chemical and atmospheric action referred to, from the rock masses they have been derived from, they would naturally, according to the nature of the intervening

ground and the length of transit from their higher source to their final deposit, be assorted into beds of varying composition—particles of undecomposed rock, grains of quartz, iron pyrites, and other impurities, being the heavier of these materials, would mostly be gradually left behind, *en route*, or deposited near the margin of the lakes or estuaries; while the finely-divided particles of clay, owing to their lighter specific gravity, would be carried beyond these, and ultimately deposited in the beds, of which they constitute the bulk, in a comparatively pure state. As the clays of the Bovey Tracey beds may probably have been carried, so far as they have been derived from the granites of Dartmoor, a distance of 10 to 12 miles, if not more, it is thus easy to account for their comparative purity. On the other hand, where any of these clays, or those of the Poole beds, have been derived from other rocks, such as chalk or clay slate, or perhaps in some cases from previously formed argillaceous sedimentary deposits, from a less distance, the freedom of those rocks or deposits from the other ingredients, associated in the granites with those constituting silicates of alumina, would as satisfactorily account for their purity.

Thus, whatever their origin, these pottery clays are found deposited in thick beds, washed and freed by Nature's hand from all such extraneous ingredients as would otherwise have prevented their employment without such preparatory processes as are necessary to produce kaolin in a state fit for potting and other manufacturing purposes.

The mode of raising the Teignmouth and Poole clays is an extremely simple one. It is thus described by De la Beche¹:—The gravel or other surface covering, or “head,” as it is called, being removed, large rectangular pits are sunk, the sides of which are supported by timbers. As the pits are sunk stages

¹ *Report on the Geology of Cornwall, Devon, and West Somerset*, by Sir H. T. De la Beche, F.R.S., 1839.

are erected, and the workmen who cut out the clay in cubical lumps, weighing from about 30 to 35 lb. each, fling them up by means of a pointed staff, from stage to stage, according to the depth, after which the lumps are carried to the clay cellars or sheds, whence they are forwarded, when sufficiently dried, for shipment to the potteries or elsewhere.

As might naturally be expected, these beds of clay, occurring thus in a state ready for use in the manufacture of pottery, were certain to be utilised, as they were, at an earlier period than that in which, owing to the increased importation of Chinese porcelain—first introduced into Europe as an article of commerce by the Portuguese, about the year 1520—(although there are notices of Eastern porcelain having found its way there twenty years or more previous to that date) an improved taste, and the consequent desire to imitate and rival the Chinese porcelain, led to numerous attempts to improve European wares, and for that purpose to find superior clays to the pottery clays then in general use. Although, however, it is said that a soft paste was made in Florence as early as 1580, it was not till 1709 that Böttcher was successful in finding china clay and in making white porcelain in Saxony. In 1710 he was appointed by Augustus II., Elector of Saxony, director of the Meissen factory, and five years later he succeeded in making excellent true hard porcelain there. That factory is still in operation, and producing the fine porcelain known as Dresden china. What clays Böttcher first used in Saxony is not known, although it is probable it was those found at Seilitz, near Meissen; but he finally employed the china clay of Aue, near Schneeberg, in the Erzgebirge, one of the best-known localities for it in Europe; where the finest porcelain clay is obtained from beds of decomposed gneiss—a metamorphosed granitoid rock, composed like granite of felspar, quartz, and mica. In gneiss the felspar often, if not generally, occurs in a soft state, and destitute of potash, or nearly so, and by decomposition thus

readily produces kaolin. This kaolin was long known as Schnorr's white earth, owing, it is said, to its discovery by John Schnorr, an ironmaster, who, riding near Aue, observed a soft white earth adhering strongly to his horse's feet. This was subsequently used and sold largely as hair-powder, as a substitute for wheat-flower, and some of it coming into Böttcher's hands, he was led, from finding it heavier than the ordinary powder, to experiment with it, which resulted in his discovering its identity, as was then supposed, with the Chinese kaolin—the substance he had long sought for the manufacture of his porcelain.

This porcelain earth of Aue, according to a report by Mr. Oelschlagel, referred to by the late John Hawkins, F.R.S.,¹ occurs in a cone-shaped, eruptive, granitoid mass, covered by micaceous slate, in two beds, separated by a bed of granite, the whole of which is in a very decomposed state; the felspar being converted into kaolin, which constitutes from a fourth to a fifth of the mass, mixed with quartz, undecomposed orthoclase felspar, mica, oxide of iron, and pinite; the purest being found at the top, and the fineness and friableness of it diminishing in depth, until it passes, through all degrees of induration, into a firm crystallisation of felspar, while the quartz and mica occur in masses easily separable by the hand.

Next to Aue, the principal spot in Saxony where the porcelain earth occurs is at the village of Seilitz, above mentioned, where it is found 20 feet thick, with a covering of clay with shells, and resting on a bottom rock of porphyry. It is mixed with quartz and particles of greyish clay; and lumps of pure kaolin of the size of a man's fist occur in the mass. This porcelain earth is more free of oxide of iron than that of Aue, but it shrinks more in the kiln, and produces a less durable porcelain. Mr. Oelschlagel's opinion of this porcelain earth is,

¹ In a paper in *The Transactions of the Geological Society of Cornwall*, vol. vi. p. 32.

that it has been formed from the decomposition of porphyry. He probably means a porphyritic granite, such as that of Cornwall and Devon, containing large prismatic crystals of felspar, by the decomposition of which the clay would be produced.

In the Principality of Passau, in Austria, Gehlen states that kaolin occurs at Kellberg, in a district of gneiss and granite, near the surface, and in a state of great, although much-varied, decomposition, the felspar, in some portions, being found in every stage of disintegration, in others, entire and unaltered. The chief deposits of the kaolin are formed, he says, by stratified masses of decomposed felspar, alternating with a very decomposed gneiss; and while the felspar, on the one hand, occurs in every possible stage of decomposition, the kaolin, on the other, exhibits various degrees of fineness, or of pulverisation, some of it being so pure and impalpable as to be wholly suspended in running water, while others retain a sort of grittiness to the touch, seemingly occasioned by an imperfect or disturbed crystallisation. From the beds at Kellberg, near Passau, the Royal Factories of Vienna and Munich are supplied with kaolin.

In 1750 the manufacture of porcelain was commenced at Berlin, and in 1763 Frederick II. bought the works there, and converted them into the Berlin Royal Factory. The Berlin porcelain is made from kaolin found at Gomritz, below Halle, in the district of Magdeburg, and at Gothenburg and Giera, in Lower Silesia.

Among the European Royal Porcelain Manufactories, that of Sèvres holds the first rank. It was purchased by Louis XV., in 1759, who appointed Boileau director, and, besides perfecting the works, the latter occupied himself in the endeavour to make hard paste, and made several attempts, by purchase and otherwise, to secure the secret of the process claimed to be in the possession of the Hannongs, of Strasburg, and others, but un-

successfully. As Jacquemart has said,¹ "The invention of real hard pottery is less within the domain of ceramic industry than of geology; there—no efforts of imagination, of creation properly so called—the felspathic rock must be had; the rest comes from one's self. Porcelain produced herself naturally the day when people, strangers to science, had laid their hand upon the sought-for clay." "And it was by chance at last," says the same author,² "that France acquired the coveted material." "One Madame Darnet, wife of a surgeon of St. Yrieix la Perche, about 10 leagues from Limoges, found in a ravine a white, unctuous earth, which appeared to her fit for washing linen. She showed it to her husband, who, more versed in the questions of the moment, suspected that this might be the clay they sought for. He ran to an apothecary at Bordeaux, named Villaris, who recognised it to be kaolin. Then took up specimens, which were transmitted to the chemist Macquer, of Sèvres. He went to St. Yrieix, in August 1765, and, after repeated experiments, was able to read to the Academy, in June, 1769, a complete memoir upon French hard porcelain, and to exhibit perfect types." The composition of the St. Yrieix kaolin, which is that used at the Sèvres factory, is—silica, 48·00; alumina, 37·00; alkalies, 2·05. It occurs there very abundantly in decomposed granite, resembling that of Cornwall. It is generally white, sometimes, from the presence of iron, of a yellowish tinge, and has very little mica. Like most of the kaolins, it is meagre to the touch, and contains a good deal of free silica, in the form of quartz grains. It makes a very transparent porcelain, and since its employment at Sèvres, the fame of the St. Cloud factory has been much enhanced, especially under the able scientific directorship of the late M. Alexandre Brogniart.

¹ *History of the Ceramic Art*, by Albert Jacquemart, 2nd edition, 1877, p. 573.

² *Ibid*, p. 578.

From the dates above given, it will appear that the discovery of china clay in this country was almost contemporaneous with its discovery in France, and not long after its discovery in the comparatively few localities in Saxony and other parts of the continent, where, as yet, it has been found. The instances, and dates of those given, may suffice, as these chapters have to do—not with the history of European, or even English earthenware and porcelain, but—solely with the potting materials themselves.

In 1745 an adventurer brought back with him to London from Virginia some kaolin, which, owing to its rarity, sold at that time for 13 guineas a ton. William Cookworthy, a Plymouth quaker and chemist, is said to have had his attention directed to this material by the person just referred to, and as he had started a pottery at Plymouth in 1733, he, it may be presumed, was much interested in it; and having a great aptitude and liking for geological research, he doubtless, during his journeyings through Cornwall, had been long searching for a superior clay to those of the Teignmouth and Poole beds, which he probably had been using in the above works. The existence of the Cornish clay and stone may have been known to him for some time ere he could favourably for his own interest make it publicly known. It has not been clearly ascertained when he first discovered them, but from a short account of his life published by his grandson,¹ it was about the year 1755, and if so, it was the first discovery of the china stone in Europe. It may be presumed that the stone was discovered by him first, and that by further investigation and experiment by levigation of the clay so often found associated with the china stone *in situ*, he found it to be kaolin. From his grandson's account he appears first to have found both the stone and clay at Tregonning Hill, near Breage, then in the

¹ *Memorials of William Cookworthy*, by his Grandson, with an Appendix, London, 1854. Also another Appendix published in 1872.

parish of St. Stephen's, and afterwards in the domain of Boconnoc, the family seat of Thomas Pitt, nephew of the Earl of Chatham, and afterwards Lord Camelford. In 1768 Cookworthy, in company with the latter and others, secured by patent the exclusive use of the Cornish china clay and stone, and with these materials, along probably with the clays of Devon or Dorset, carried on the manufacture of porcelain for some years at the Plymouth pottery, which undoubtedly was the one at which "hard" or true porcelain was first made in England. Borlase, in his *Natural History of Cornwall* (1758), mentions white clays at Tregonning Hill, but without being aware of their nature evidently. He states that Cookworthy had made experiments on the Breage china stone, and that it had been found useful for the manufacture of porcelain. Pryce, in his *Mineralogia Cornubiensis*, published in 1778, states "that artificial kaolin (china clay) was then prepared in the parishes of Breage and St. Stephen's by repeated washing with clear water, and afterwards packed in casks and sent off, and that Mr. Cookworthy, by his late improvements at his porcelain manufactory, then established at Bristol (having been removed thither from Plymouth), was likely to produce ware which should rival the best Asiatic china."

CHAPTER VIII

CORNISH CHINA CLAY—COMPOSITION AND ANALYSES

PORCELAIN clay is the purest form of hydrated silicate of alumina, and is a substance of comparatively rare occurrence in a natural condition. Even the material from which it is generally artificially produced has as yet been found in Europe but in few localities; and in England only in the granite rocks of Dartmoor in Devonshire, and in those of Cornwall. From the fact of the great bulk of its production in England being from the latter county, it is often called Cornish clay; but the name by which it is best known, and which is that generally used by potters, is that of china clay. Outsiders—scientists and others—usually call it kaolin, but, if by that is meant that it is really identical in composition with the Chinese kaolin, it is questionable if that name be not a misnomer when used for Cornish clay. Kaolin, however, has been so long in general use, and is so short and convenient, that it will probably continue to be used for Cornish clay, so long at least as people are satisfied to use such names as shell-fish for molluses, which are not fish at all; or blacklead for graphite, of which pencils and crucibles are made, and which has not an atom of lead in its composition. The Chinese porcelain clay will be referred to at length. In the meantime, however, it may be suggested that “clarelazin” would be a more correct scientific name for Cornish clay than that of the Chinese term kaolin, as being derived from the further decomposition of the granitic rock, for which the name of “clarelazite” has been proposed by Mr. Collins,

in his valuable monograph of *The Hensbarrow Granite District*.¹

Mr. Collins' monograph treats so fully of china clay and its production, that it ought to be in the hands of every potter who takes any interest whatever in the materials which he employs or works with.

There are many persons, however, in every trade who do not interest themselves in the natural history of the materials with which they work; and while space cannot be afforded in its pages for such full details as are requisite for the completeness of monographs of the various materials used by the trade, its proprietors have been encouraged to provide such popular accounts of these as may be likely to awaken a scientific interest in them, amongst those of its readers who may not hitherto have thought of them in this way.

Although, as will be shown hereafter, there are other rocks than granite from which china clay might be, and probably before long will be, produced, its production as yet has been confined in England to the material known in Cornwall as soft "growan," which is a more or less decomposed granite. It is by the decomposition of the felspar of the granite, which is its base, and constitutes never less than a third and generally at least one-half of its bulk, and sometimes even more, that its disintegration occurs. It has been shown² that in the largest granitic mass in the United Kingdom, that, namely, which runs south of Dublin, for a length of 70 miles or so, the granite contains 52·94 per cent. of felspar, while the composition of the granite of Slievenaglogh (Mourne Mountains)

¹ *The Hensbarrow Granite District*, by J. H. Collins, F.G.S. Lake & Lake, Truro, 1878.

² In a paper on the "Lower Palæozoic Rocks of the South-East of Ireland," by Professor Haughton and J. Beete Jukes, *Trans. R. I. Academy*, vol. xxiii.

shows a still larger proportion of felspar, it being composed of—

Quartz	20·70
Felspar	66·37
Mica	12·76
	99·83

and the felspar of the Hensbarrow granite forms two-thirds, or 66·66, of the mass, according to Dr. Berger.¹ Professor Haughton² holds that the granites of Cornwall were, in their primitive condition, of igneous, and not like many other granites, of aqueous origin, but they are of a much looser texture than most granites, and therefore more readily disintegrated by atmospheric influences. Mr. Sorby, F.G.S., who is so famous for his microscopical examinations of rocks, concludes that the granites of the Scottish Highlands indicate a pressure when being consolidated of 26,000 feet more than in the case of the granites of Cornwall.³ This may help to account for the fact of their being, in some localities, so generally reduced to the condition of gowan, and of the absence of a similar material in most other granitic districts.

The felspar of the Cornish granites is generally that known as orthoclase, a potash felspar; and it is mainly from the decomposition of this that the china clay is produced. Its composition may be given as follows, viz.:—

Silica	65·50
Alumina	16·80
Potash	17·70
	100·00

¹ *Geological Transactions*, O.S., vol. i.

² *Manual of Geology*, by the Rev. Samuel Haughton, M.D., F.R.S., p. 41.

³ "Observations on Granite," *Geological Society's Journal*, vol. xiv. pp. 453, etc.

This shows it to be rich in potash, and if this alkali was retained in the china clay, it would become fusible and unsuitable for the manufacture of porcelain, the refractoriness of the clay being entirely due to the absence of alkalies or alkaline earths. Its composition may be given as—

Silica	46.40
Alumina	39.70
Water	13.90
	100.00

Now in comparing these two substances, it will be at once seen, that of the silica of the felspar 19.10 has disappeared, and that, while the whole of the potash, 17.70, has also gone, the alumina has been increased by 22.90, while the net loss of 13.90 has been replaced by water, thus—

Silica	-19.10	} +	Alumina	22.90
Potash	-17.70		Water	13.90
	36.80	=		36.80

Some geologists maintain that china clay results from the decomposition of the white soda felspar, albite, an ingredient of some granites. Professor Ansted, for instance, says: "The kind of granite which most readily decomposes is that whose felspar is of the variety called albite, a pearly white variety in which soda replaces the potash of ordinary felspar."¹ Its composition may be given as—

Silica	69.30
Alumina	19.10
Soda	11.60
	100.00

¹ *Lectures on Practical Geology*, by Professor D. T. Ansted, M.A., F.R.S. Hardwicke, 1865.

And comparing this with the foregoing formula of china clay, it will be noticed that in this case 22·90 of the silica has disappeared, and the whole of the soda, 11·60 = a loss of 34·50, while there is an increase in the alumina of 20·60, and the addition of 13·90 of water, thus showing—

Silica	.	.	-22·90	}	+	Alumina	.	.	.	20·60
Soda	.	.	-11·60			Water	.	.	.	13·90
34·50				=		34·50				

As in the other case, the alkali soda, if retained, would also destroy the refractory character of the clay.

Now the question will at once present itself to anyone looking at these results of the decomposition of the felspars—what has taken place by which the plastic refractory china clay is produced from a highly fusible, anhydrous, and unplastic material?

In an interesting article on Cornish china clay by Mr. James Quick,¹ it is affirmed that “No generally accepted conclusion has yet been arrived at as to the direct causes of the formation of kaolin. Indeed,” he says, “no very great amount of scientific inquiry has yet been brought to bear upon the subject. *Watt’s Dictionary of Chemistry*, vol i., says: ‘Kaolin may be supposed to be formed from orthoclase or $K_2OAl_4O_3, 6SiO_2$, by the abstraction of the whole of the potash and two-thirds of the silica, and the addition of two atoms of water’; but offers no suggestion as to how this may by nature be brought about.”

On this point, as may be supposed, opinions of chemists and geologists differ; but briefly it may be taken for granted that atmospheric agencies are the chief agents in producing the growan from which the china clay is separated by the action of water. One such agency is undoubtedly that of carbonated water; rain water absorbs about twice its volume of carbonic

¹ *Quarterly Journal of Science* for October 1877.

acid from the atmosphere, and in acting upon the felspar it combines with the alkalies, and forms soluble carbonates of potash and of soda, and these are carried off by the rainfall or streams from the higher regions where the granites are generally found, and conveyed to the valleys and low-lying grounds, where they supply the necessary aliment to the soil, for the nourishment of grain and other crops. The silica is set free—a certain part of it combines with the alumina and water to form the hydrous silicate of alumina, clay; or part of it remains uncombined, and is carried off in solution or otherwise.

Mr. Collins quotes Von Buch's observation of the constant occurrence of fluorine minerals with china clay, and his opinion that the clay in the neighbourhood of Halls owed its origin to the action of hydro-fluoric acid upon the felspars; and also that of Daubrée, who, writing in 1841 of that in the neighbourhood of St. Austell, stated that it must have had a very similar origin (*Monograph*, pp. 34 and 35).

He further states that the clay "of the Hensbarrow granite," and, in his belief, "that of all other parts of Cornwall and Devon, is accompanied invariably by lepidolite" (which contains 4.81 of hydro-fluoric acid), "and almost invariably by tourmaline" (which contains 2.50 of fluorine), "so that fluorine in considerable proportions is never absent," and, indeed, "is everywhere present in the china clay districts." He describes its action on the felspar, which he believes "would readily give up its alkali (and part of its silica also) to the fluorine or decomposable fluorides, and be thereby reduced to the state of silicate of alumina—part of the alkaline fluoride passing away in solution, the rest being deposited with the silica as lepidolite among the particles of kaolin."

By which of these chemical agencies the china clay may have been or is produced it may be difficult to decide with certainty. Probably both have had a large share in the decomposition of

the granite that has taken place in Cornwall on so extensive a scale, and both are probably still in constant operation in the production of "growan." Mr. Collins states that a high temperature is not essential to the action of fluorine in the decomposition of felspar, for, he says (p. 36), "I have kaolinised orthoclase, and also the felspar of the Cheesewring granite by means of hydro-fluoric acid at ordinary temperatures, without apparently affecting the other ingredients of the granite."

In the introduction to the *Catalogue of Specimens in the Museum of Practical Geology*, it is stated (p. 3) that "the potash, soda, lime, or oxide of iron that may be present in the original felspar (from which the china clay is derived) is removed to a great extent in the form of soluble carbonates or bicarbonates by the action of water holding carbonic acid gas (carbon dioxide) in solution"; and referring to the felspars which are important as constituents of rocks, "the chief species of which are orthoclase, albite, oligoclase, labradorite, and anorthite," it is stated, that while all these are "liable to decomposition, under certain conditions, and may thus yield clay-forming materials, it is observable that those species which are poorest in silica, and which contain much lime, are more readily decomposable than those which are richer in silica and contain less lime, but more potash and soda. Thus, it may be inferred that labradorite and anorthite are more subject to alteration than are the more highly silicated felspars—orthoclase, albite, and oligoclase. It is, however, the three latter which have yielded the base of all our ordinary clays, and of these again, orthoclase may, perhaps, be regarded as that species which has done so most abundantly." The anomaly involved in the above quotation is one requiring further elucidation, if the presence and action of fluorine may not account for it.

CHAPTER IX

CORNISH CHINA CLAY

IN the last chapter, reference was made to the Chinese kaolin, which it was proposed to discuss more fully in this one, but as we had not finished what remained to be said about Cornish clay, the subject of Chinese kaolin must be postponed for the present.

Cornish porcelain or china clay is mineralogically described by Dana and others, as occurring massive, or disseminated, in rhombic, rhomboidal, or hexagonal scales or plates, sometimes in fan-shaped aggregations, usually constituting a clay-like amorphous mass, composed of small particles, which possess only a slight degree of coherence (and, therefore, somewhat deficient in plasticity); compact, friable, or mealy. Colours generally various shades of white or greyish-white, but sometimes—from the presence of iron or other impurities—yellowish, brownish, bluish, or reddish. Opaque, sectile; adheres slightly to tongue, soft and meagre to the touch when dry, unctuous and plastic when wet. Lustre, pearly to dull earthy. Insoluble in acids, but decomposed by hot sulphuric acid, which dissolves the alumina and leaves the silica. Gives a blue colour with cobalt solution, H., 1·0—2·25; sp. gr., 2·21—2·63; B.B., infusible.

Composition—Hydrous silicate of alumina, viz. silica, 46·40; alumina, 39·70; water, 13·90, as already given. Ordinary china clay under the microscope, if not without, is seen to be largely made up of minute six-sided scales or plates of pearly lustre, translucent, flexible, inelastic, usually unctuous and plastic.

China clays possess very characteristic properties. They are of a loose earthy texture, and light, friable in the hand, meagre to the touch, and do not readily form a plastic paste with water. Their composition is different from different localities, the limits being very wide. Professor Ansted gives¹ the following analysis as that of their average composition, viz. :—

Silica	44·60
Alumina	44·30
Oxide of iron	·20
Lime and magnesia	1·60
Water	8·74
Loss	·56
	100·00

But samples sometimes, he says, contain as much as 10 or 12 per cent. of free silica, either as fine or coarse sand, mixed with the clay.

In the above analysis he overstates, however, the percentage of alumina, which rarely reaches or exceeds 40 per cent.; and the undernoted ones which he gives as that of the finest china clay, is much nearer the mark, viz. :—

Silica	46·32
Alumina	39·74
Oxide of iron	·27
Lime	·36
Magnesia	·44
Water	12·67
Loss	·20
	100·00

The Cornish and Devon porcelain clays generally contain some spangles of white mica and finely comminuted quartz, which indicate their origin from granites. They are nearly all

¹ *Applications of Geology to the Arts and Manufactures*, by Professor D. T. Ansted, M.A., F.R.S., p. 116,

artificially derived from the decomposition (as it is generally believed) of the felspar in the schorlaceous and other granites, which are so abundant in the St. Austell and other districts of Cornwall, and of Dartmoor in Devonshire. Of these, pegmatite, a binary granite, is composed of quartz or felspar, but often containing small flakes of silvery white mica; and protogene, a talcose granite (like that of the Alps, which however has in some places a dull mica, or chloritic mineral instead of talc) is composed of quartz, felspar, and talc. The latter derives its name from an erroneous idea that it is the first formed, or oldest of the granites; whereas De la Beche has shown that the Cornish granites belong, like those of the Alps, to the secondary formations, and are indeed newer than the carboniferous.

The Cornish china clay is chiefly derived from the decomposition of protogene—a granite which contains talc as an ingredient, and is peculiarly liable to undergo extensive disintegration. When schorl is present, as it often is in veins and cavities of these granites, it has, of course, to be carefully separated, along with the other impurities, in preparing the clay.

Dr. Boase states¹ that “protophene granite is, of all others, the most extensively disintegrated, in which state it is provincially called china clay. It abounds in St. Stephen’s and the adjoining parishes, and in Tregonning Hill, near Breage, and affords an interesting subject for geological inquiry. The formation of this substance (china clay) is generally attributed to decomposition. It must, however, be acknowledged that, if such be its origin, the elements have, in this instance, greatly transcended their usual operations.”

The proportions of the constituents of granite vary indefinitely—with this limitation, that the felspar is always,

¹ “On the Geology of Cornwall,” by Henry S. Boase, M.D., *Trans. Royal Geo. Society of Cornwall*, vol. iv. p. 379.

with quartz, an essential ingredient, forming a large proportion of the whole, as noticed in Chapter VIII., the mica, however, sometimes being barely perceptible—and owing both to that, and also to the varying state of decomposition in which it occurs in the various localities where it is worked for the clay, the latter also varies much in composition, as will be apparent from the various analyses which will be given hereafter.

In a communication, with which the writer was lately favoured, from Robt. W. Armstrong, Esq., of Belleek, Fermanagh, he gives the following as examples of the varying composition of the Cornish granites, from which the porcelain clays are derived, viz. :—

Silica	.	.	.	.	.	.	.	70·0 to 74·0
Alumina	.	.	.	.	.	.	.	16·0 „ 18·0
Potash	.	.	.	.	.	.	.	8·0 „ 5·0
Soda	.	.	.	.	.	.	.	0·0 „ 3·0
Lime	.	.	.	.	.	.	.	1·0 „ 1·0
Magnesia	.	.	.	.	.	.	.	0·0 „ 0·5
Water	.	.	.	.	.	.	.	4·0 „ 0·0
								99·0 101·5

Mr. Collins states,¹ that “in each of the granite masses which rise like islands in the sea of clay slate forming the western extremity of England, some portions have their felspar so decomposed as to be converted into china clay. Other portions are less decomposed, and are of somewhat different composition, and these supply the china stone. These decomposed portions are always associated with veins of black tourmaline (schorl) and other minerals containing fluorine”; and he states that, in his opinion, the decomposition of the felspar “has certainly been effected by fluorine and other substances coming up from below, and not by carbonic acid and water acting from above.”

¹ “On the China Clay and China Stone of Devon and Cornwall,” by J. H. Collins, F.G.S., *Journal of the Society of Arts*, vol. xxiv. p. 566.

He states also that "the natural china-clay rock, being a decomposed granite, consists of kaolin, irregular crystals of quartz, and flakes of mica, with sometimes a little schorl and undecomposed felspar." In the discussion which followed the reading of his paper, he further stated that the "bulk of china clay came from granite which had been decomposed *in situ*, in his opinion, because they could often see its gradual passage from china-clay rock (clarelazite), and large porphyritic crystals of felspar could often be seen changed into kaolin without losing their form."

In opposition, however, to the theory of decomposition of the felspar, whether from above or below, Mr. John Hawkins, F.R.S., maintained the opinion that the soft growan, from which the china clay is obtained, is in its original condition; the lapidifying power having been arrested, or not as yet having extended so far upwards; and in corroboration of this opinion he states¹ that at the Beam mine, in the parish of Roche, Cornwall, the works are "actually sunk alternately through hard and soft growan," which fact will scarcely sustain the inference he draws from it, as it may equally well be adduced as proof of incomplete decomposition; but he further refers to various sections of that mine, and states that "from these it appears that the hard growan occurs nowhere in the upper levels of the mine, and that it occupies a small portion only of the lower; that it alternates with the soft growan; that it is not always found at corresponding levels, and that it terminates abruptly in a line which corresponds with the underlie of these veins."

Mr. Hawkins, in support of his theory, refers to several clay pits on Hensbarrow, and on the hills of St. Mewan,

¹ "Some Account of the Soft Growan at the Beam Mine, in the Parish of Roche, and at Carelaze Mine in the Parish of St. Austell," by John Hawkins, Esq., F.R.S., *Trans. Roy. Geo. Soc. of Cornwall*, vol. iv. p. 475.

but states that "the most striking evidence of the aboriginal existence of the soft growan is perhaps that which is displayed at the celebrated excavation at Carelaze, in the parish of St. Austell, where its removal is effected by a stream of water—the growan being in such a condition there that it may be called a clay-pit. The growan exhibits no marks of sedimentary or of stratified divisions," and in the "arrangement or distribution of its constituent parts, it differs in no respect from the hard growan. In short, there are no traces of any change or disturbance, and every part of the mass seems to be in the same state of induration; the lodes, too, which traverse it bear, like the same lodes in the Beam mine, no marks of either dislocation or displacement, and, moreover, so compact is the mass of this soft rock, that I conceive it hardly possible for any rain to penetrate through it, without which it is difficult to support the hypothesis of decomposition." He further quotes from Captain Samuel Robins, who states: "There is no reason whatever to believe that any water whatever can filter through the soft growan. We have sunk from 10 to 15 fathoms through it without meeting with any water, which only occurs when we meet with a lode or a cross course, and were it not for these we should find none. The mass of soft growan cannot be called dry, neither is it moist; but it is everywhere much in the same state as it is near the surface—a little damp." However these facts may appear to bear against the general opinion of sub-aërial decomposition, they do not affect Mr. Collins' theory of decomposition, by the agency of fluorine and other substances coming from below.

Dr. Boase (in the same paper as that above quoted, p. 380) says: "That the gradual diminution in the cohesion of the particles from the solid rock upwards will, of course, support the opinion of either party; but that the solid state of the one, and the disintegrated state of the other, is not the only difference; there is a chemical, as well as a mechanical, distinc-

tion ; for the solid felspar contains an alkali which analysis has not detected in porcelain clay, and it therefore follows, since an alkali is not present in the perfect china clay as a constituent part chemically combined, that this substance, on account of its great solubility in water, cannot exist in a free state in the mass of china clay (soft growan), which, in its native bed, is always wet, for by the constant percolation of water it would be as effectually removed (naturally) as in the process itself, by which the porcelain clay is prepared. It may also be observed, that the stained parts, which the workmen reject under the name of 'weed,' are of a yellowish or red colour, indicating that the iron contained in the schorl has passed into a higher state of oxidation"; and as those beds of soft growan are generally bounded by solid granite, and are often traversed by large masses and veins of quartz containing schorl, Dr. Boase quotes these circumstances as another argument against Mr. Hawkins' opinion, for he says : "It is difficult to conceive why the power (lapidifying), whatever it might have been, should have acted so partially in its operations, as to have consolidated one part of the mass, and to have left the other in a loose, friable state. Again, the partially changed granite, called china stone, will in time entirely lose its cohesion"—an evidence of sub-aërial decomposition in the writer's opinion—"as may be seen in the numerous masses around the quarries, which, although retaining their form, immediately crumble into pieces on attempting to remove them. And, lastly, the analogy of other rocks affords, perhaps, the best proof that china clay is a decomposed granite."

It will be noticed from the above, that Mr. Hawkins and Dr. Boase—both of whom are intimately acquainted with, and have written upon, the geology of Cornwall—are at direct issue, not merely on a theoretical question, but on a matter of fact. Mr. Hawkins, backed by the experience of Captain Robins, stating that the soft growan is only in a damp state

normally, and that water cannot percolate through it. Dr. Boase, on the other hand, stating that in its native bed it is always wet, and that the absence of the alkali of the felspar in the china clay is due to its great solubility, and to its being effectually removed by the constant percolation of water through the growan.

There are not a few, as yet, unsolved problems connected with this subject, and one object the writer has in view is to direct further attention to it, with the view of stimulating inquiry and discussion. Mr. Carne states¹ that "the china-stone of St. Stephen's might perhaps be mentioned as another variety of granite; but," in his opinion, "it owes most of its difference from ordinary granite to decomposition." The opinion of Mr. Carne, which prevails very generally, is, Dr. Boase remarks (p. 381), "very surprising, for this property of undergoing such extensive decay is alone sufficient to indicate that it (the St. Stephen's granite) is a rock *sui generis*; besides, it is peculiar in composition, containing talc instead of mica; which circumstance," he says, "may afford a clue to the explanation. Not that the talc itself can be supposed to exert any direct action on the felspar; but, in consequence of its having been formed, instead of mica, in the original crystallisation of this rock, the felspar may have experienced some modification in the proportion of its constituent parts, whereby it acquired the property now under consideration."

This presence of talc—which is a mineral, containing as much as 32·92 of magnesia—in numerous greenish-yellow glossy scales in the St. Stephen's granite, however it may have affected the constitution of the felspar, but seldom occurs in the china clay, for in nearly all the analyses of it there are but traces, or very small quantities of it, to be found. The magnesia, like lime, being an alkaline earth, is carried off in

¹ "On the Granite of the Western Part of Cornwall," *Transactions of Royal Geographical Society of Cornwall*, vol. iii. p. 212.

solution like the alkalies. It would be an advantage for the refractory quality of the Cornish clay did it contain more, as is generally the case with the Chinese kaolins.

The essential and striking difference in composition between china clay and the felspathic growan (Mr. Collins' clarekzite) from which it is produced, and which was shown in the last chapter, has led to the opinion being held by some mineralogists and chemists, and specially by Professor Fuchs, of Landshut, that ordinary felspar is not the source of china clay. Professor Fuchs, in a memoir on the origin of the porcelain earth of Passau, printed in the *Transactions of the Royal Academy of Munich*, and quoted by Mr. John Hawkins,¹ states that he visited the pits where the best earth was dug, and directed his attention particularly to the felspar, said by Gehlen to form by its decomposition the porcelain earth, and found that the mineral so named was essentially different in its form of crystallisation and characters from ordinary felspar. He described the rock in which the crystals of this mineral substance lie, as "a fine-grained or aggregated felspar, of a greyish colour. Few of the crystals were entire, but nearly all of them, more or less decomposed, and the friable mineral had all the properties of porcelain earth." His analysis of them gave:—

Silica	.	.	.	.	.	.	.	.	.	.	49·30
Alumina	.	.	.	.	.	.	.	.	.	.	27·90
Lime	.	.	.	.	.	.	.	.	.	.	14·42
Soda	.	.	.	.	.	.	.	.	.	.	5·46
Water	.	.	.	.	.	.	.	.	.	.	0·90
											—
											97·98

¹ "Some Account of the Porcelain Earth found in the Kingdom of Saxony and the Principality of Passau, collected from German publications, and sent to the Royal Geographical Society of Cornwall," *Transactions*, vol. vi. p. 32.

Professor Fuchs, from this result, and the form of its crystallisation, as well as its other characters, considered this mineral as a new species, distinct from any known species of felspar, and named it porcelain-spar. His analysis of the earth formed, as he believed, from the decomposition of this mineral, in its pure and natural state, he gives as :—

Silica	46·70
Alumina	31·80
Lime	0·46
Oxide of iron	0·82
Felspar ¹	3·00
Water	17·14
	99·92

and he seemed to regard the porcelain earth of Aue, in Saxony (which, by the bye, appears now to be exhausted), as having been precisely similar.

Mr. Hawkins says, that the principal arguments upon which Professor Fuchs vests his opposition to the opinion, held by most mineralogists, of porcelain clay being produced by the decomposition of felspar, are—"The total absence of all traces of potash in the waters which flow from the decomposed masses of granite, and the occurrence of the purest porcelain earth enclosed in felspar, and, *vice versa*, of felspar in porcelain earth." Professor Fuchs was by no means disposed to adopt the opinion, held and advocated by Mr. Hawkins, of this earth (china clay) being an original product of Nature, but, on the contrary, held it to originate in the decomposition of porcelain-spar, the mineral he claims to have discovered. As to the process of decomposition, he thought it might be satisfactorily explained, "for in such a complicated mixture as this is, the presence of soda and the calcareous earth (lime) must have disposed the porcelain-spar to yield to the active agency of

¹ Undecomposed and accidentally mixed.

water and the carbonic acid, by which all the soda and the lime have been carried off in a state of solution, together with a portion of the silica."

Mr. Hawkins naturally points out that Professor Fuchs, by this statement, places himself in a dilemma, there being no traces to be found of the soda and lime in the water flowing from the decomposed porcelain spar any more than of the potash from decomposed felspar, and Mr. Hawkins proceeds to controvert Professor Fuchs' conclusions. Sufficient space, however, is not available in these pages to do more than indicate the various theories or opinions held on the subject, and the writer must refer those interested in it to Mr. Hawkins' paper itself.

In that paper he proceeds to refer to a report drawn up by Mr. Gehlen, first published in the *Transactions* of the Royal Academy of Munich, and afterwards reprinted in the second volume of Von Moll's *Annals of Mining and Metallurgy*, upon the porcelain earth found in the principality of Passau, which supplies the royal manufactories of Vienna and Munich. In that report Mr. Gehlen says: "It remains for me to speak of the natural history of this porcelain earth. I have already quoted the opinion, which is universally adopted, of its originating in the decomposition of the felspar, and noticed its occurrence in a country of primitive formation, as well as the circumstance of its being found in its original position. This opinion of the origin of the earth is corroborated, in fact, by all the circumstances under which it occurs, both at Passau, and at Aue, in Saxony, where the beds of porcelain earth lie in a rock of granite, which, by the decomposition of the felspar, is in a state of perfect disintegration. The various degrees, too, of decomposition through which the felspar passes, in which, with the loss of all its other characters, it retains those of its original structure, seem to confirm this hypothesis. On the other hand, if we contemplate the very great difference which is found between the chemical composition of the felspar

and that of the earth (china clay), we must feel inclined to the belief that they can have no common origin, and that each is aboriginal. According to the recent analyses of the best chemists, the felspar contains a very great proportion of silica, as well as a considerable quantity of potash, while the porcelain earth is found to contain not a trace of potash, and a much smaller proportion of silica." He might have added, "and a much larger proportion of alumina." "How then," he proceeds to ask, "can so considerable a difference as this is in the composition of these two substances have arisen from a process of decomposition? If we suppose this process to have set free the potash, which was afterwards carried off by water, yet it is but reasonable to suppose that the proportions of the other constituent parts would have remained unaltered. This difficulty cannot be removed by the supposition that the potash may have carried off a portion of the silica in a state of solution, and thus have increased the relative proportion of the alumina; for there are many chemical facts which oppose this conjecture, and it must be abandoned as untenable."

Mr. Gehlen concludes without advancing any fixed opinion upon this very interesting question, "nor," adds Mr. Hawkins, "can I find among the voluminous writings of the German geologists any serious attempt made to settle it. The hypothesis of the secondary origin of porcelain-earth seems," he says, "to have been generally adopted on the Continent." Mr. Hawkins, however, apparently holds to his own opinion of the soft growan, from which it is obtained in Cornwall, being not a product of decomposition, but an original formation, not perfectly lapidified.

The writer cannot presume to attempt to solve the problem, but he may remark, as a contribution towards it, that the question of time does not seem to have been sufficiently taken into account by those who have speculated upon it. Mr. Collins, in his monograph previously quoted, says (p. 6) that

“China clay, in its natural state, is simply a granite composed of white or pale smoky quartz, white mica, sometimes a little greenish-yellow gilbertite, and white felspar, in which the latter is partly or completely metamorphosed into kaolin,” and he states that “this modification of granite occurs in areas of irregular form, and extending to an unknown depth.” It has thus been apparently completely decomposed *in situ*, and to some considerable depth, and thereby reduced to such a condition that if Mr. Hawkins’ statements quoted above can be relied on—it has become, like the ordinary and more plastic clays, impervious to the percolation of water, and in consequence the process of decomposition being so far completed, at all events so far as surface deposits are concerned, little or no evidence can be found of potash being now carried off in solution, as in ages past when the process of decomposition was in active operation. When it was so, the action would be continuous, and the alkalies and alkaline earths, and portions of the silica being continuously carried off in solution, would leave an ever-increasing percentage of alumina to combine with the remaining silica—these two substances possessing great affinity for each other—to form with water the hydrous silicate of alumina or china clay, that being a very different process, however, from that of converting a single piece, or any given portion of felspar, into china clay—bulk for bulk.

CHAPTER X

ANALYSES OF CHINA CLAY—METHODS OF OBTAINING AND PREPARING CORNISH CHINA CLAY

IN the preceding remarks on Cornish china, or porcelain, clay; its origin, nature, characteristics, and composition have been noticed, and various opinions and theories referred to, and more or less briefly discussed, as to the species of granite¹ from the disintegration of which it is derived, and as to the felspathic ingredient thereof—whether orthoclase

¹ The writer regrets having inadvertently overlooked a footnote in Mr. Collins' monograph of the *Hensbarrow Granite District*, in which, referring to the statements by many writers of protogene granite being abundant in the decomposed granite districts of Cornwall, he states that, whatever may be the case elsewhere, "there is certainly nothing of the kind at present known in Cornwall." This is certainly remarkable after the positive statements of Dr. Boase, quoted in the last chapter (p. 59, viz., that "protogene granite is, of all others, the most extensively disintegrated, in which state it is provincially called china clay, and that it abounds in St. Stephen's and the adjoining parishes, and in Tregonning Hill, near Breage"—another striking instance of disagreement as to observable facts by two competent observers, both intimately acquainted with the geology of Cornwall, and both of whom have written upon it. Cookworthy called the "caulin" a white *talc*y earth, found in Cornwall. Professor Sedgwick called the granite of Tregonning Hill chiefly a talcose granite—protogene, the talc sometimes white, but often of a pale yellow passing into light green. Mr. Henwood, too, says that in the north, central, and east parts of Cornwall the granite is sometimes very talcose, and that at Bedlam Green there is a formation of protogene. Dr. Page also says, in his *Handbook of Geology*, that protogene abounds in Cornwall, and that the china clay of Cornwall is chiefly derived from its decomposition.

(potash) or albite (soda) felspar, or an altogether distinct species, named by Professor Fuchs "porcelain-spar"—which, both from its composition, already given, and an analysis of it from Obernzell, in Bavaria, given in Bristow's *Minerology*, viz., silica 49·20, alumina 27·30, lime 15·40, soda 6·50, chloride of potassium 1·20, water 1·20 = 100·80, appears to be a soda lime felspar—by the decomposition of which, and a new combination of its constituent ingredients, generally exclusive of the alkaline, this hydrated silicate of alumina has been produced. Differing statements as to the condition of the soft growan of Cornwall and Devon, and various opinions or theories as to the agencies by which that has been produced, and unsolved problems in connection therewith, have been mentioned, with the view of inviting further investigation on the part of readers who may have opportunities for observing the phenomena presented by the varying stages of the disintegration and decomposition of granite and the formation of growan.

Before proceeding to describe the processes by which the soft growan is worked, and the clay washed and prepared for market, it may be of some practical service to quote some analyses of porcelain clays from various localities, both English and foreign—reserving those of China and Japan till the next chapter, as these vary considerably in composition, and may be interesting to any who have not hitherto studied the variable composition of these clays.

In a former chapter the composition of fine Cornish china clay was given as silica 46·40, alumina 39·70, water 13·90; and an analysis of the finest quality, by Professor Ansted, was quoted, giving the proportions of silica and alumina respectively as 46·32 and 39·74; and also another given by him, with these ingredients, in the proportion of silica 44·60, and alumina 44·30; but with the remark, that the proportion of the latter in porcelain clays rarely reaches or exceeds 40 per cent. In an excellent treatise, however, by a writer whose

name is not given,¹ but who appears to be well acquainted with the subjects on which he writes, it is stated (p. 32) that Wedgewood found by analysis that fine Cornish clay, in the state of an extremely white and fine powder, contained 20 parts of silica and 60 of alumina. It is very questionable if this could have been a correct analysis of any of the ordinary Cornish porcelain clays. It was more probably an analysis of a felspar, as Gehlen gives one of felspar from Kellberg, near Passau, showing its composition to be silica 63·0, alumina 20·0, besides potash, lime, and some iron, but the differences in the composition of the clays are certainly worthy of notice, by potters especially.

In the *Catalogue of Specimens in the Museum of Practical Geology, London* (p. 17), the following analyses of clay from Bluebarrow and St. Stephen's, Cornwall, made by Dr. Lyon Playfair, in 1852, are given, viz. :—

	Bluebarrow.	St. Stephen's.
Silica	45·52	46·38
Alumina, with peroxide of iron . . .	40·76	38·60
Lime	2·17	3·47
Potash, with trace of soda	1·90	1·77
Magnesia, phosphoric and sulphuric acids.	traces	traces
Water, with small quantity of organic matter	9·61	9·08
	99·96	99·30

Dr. Thos. Thomson, late Professor of Chemistry in the University of Glasgow, gives an analysis, made by himself, of china clay from St. Austell, as follows :—

Silica	37·10
Alumina	24·48
Carry forward	61·58

¹ *Treatise on the Origin, Progressive Improvement, and Present State of the Manufacture of Porcelain and Glass.* Longman & Co., London, 1832.

	Brought forward	.	.	.	61·58
Lime	.	.	.	.	9·28
Ferric oxide	.	.	.	.	6·98
Water	.	.	.	.	19·22

Sp. gr. 2·484.

97·06

From the small percentage of alumina and the large amount of lime, and oxide of iron, this must have been a very inferior specimen of St. Austell clay.

Rose (Karsten's *Tablellen*, p. 37) gives the following analysis, without mentioning the locality, in which the alumina is certainly much in excess of the general run of Cornish clay, viz. — silica, 52·00; alumina, 47·00; oxide of iron, 0·33 = 99·33.

In Green's *Geology for Students*, the following analysis is given as that of the best china clay, viz. :—

Silica	.	.	.	.	.	.	.	.	46·32
Alumina	.	.	.	.	.	.	.	.	39·74
Magnesia	.	.	.	.	.	.	.	.	0·44
Lime	.	.	.	.	.	.	.	.	0·36
Ferric oxide	.	.	.	.	.	.	.	.	0·27
Water	.	.	.	.	.	.	.	.	12·67

99·80

This is one of a pure and very infusible clay, but unfortunately, its locality is not given.

In Bristow's *Mineralogy*, the following analysis of the clay from Plympton, Devonshire, by Brogniart and Malaguti, is given, viz. :—

Silica	.	.	.	.	.	.	.	.	44·26
Alumina	.	.	.	.	.	.	.	.	36·81
Lime, magnesia, and potash	.	.	.	.	.	.	.	.	1·55
Iron and manganese	.	.	.	.	.	.	.	.	traces
Non-argillaceous residue	.	.	.	.	.	.	.	.	4·30
Water	.	.	.	.	.	.	.	.	12·74

Sp. gr. 2·25.

99·66

Mr. Collins, in his monograph (p. 29), quotes from the *Phil. Mag.*, vol. x., the following analyses of clays, by Dr. Boase, from the St. Stephen's and Breage mines, viz.:—

	St. Stephen's.	Breage.
Silica	39·55	40·15
Alumina	38·05	36·20
Magnesia	1·45	1·75
Alkalies, insoluble and soluble	8·70	9·50
Water	12·50	11·65
	100·25	99·25

And he gives the following analyses, made by himself, of clays prepared for the market, to show the variation which exists in the clays from different parts of the Hensbarrow district, viz.:—

	From St. Stephen's			
	A	B	C	D
Silica	45·00	45·10	46·86	46·44
Alumina	40·15	40·11	39·59	40·22
Lime	—	—	—	0·22
Peroxide of iron	0·35	0·60	0·27	0·25
Alkalies, insoluble and soluble	0·80	0·29	0·41	0·53
Water	13·70	13·90	12·87	12·34
	100·00	100·00	100·00	100·00

And from St. Austell, E and F, and from Roche, G.

	E	F	G
Silica	46·20	46·00	45·40
Alumina	41·10	40·10	40·30
Lime and Magnesia	—	traces	traces
Peroxide of iron	0·20	0·40	0·20
Alkalies, insoluble and soluble	trace	0·40	0·60
Water	12·50	13·10	13·50
	100·00	100·00	100·00

And for comparison he gives the following analyses from various localities elsewhere, chiefly in Devonshire :

	From Devon, by Berthier.	Ditto, by Fownes.	Ditto, by Wagner.	Ditto, by Collins.	From St. Neot's, by Collins.
Silica	50·51	47·20	10·00 free 34·00 combined	46·90	49·10
Alumina	38·18	38·80	36·80.	38·35	40·20
Magnesia	—	0·24	—	trace	—
Peroxide of iron	—	—	—	0·07	0·40
Alkalies, insoluble and soluble	—	1·76	4·30	1·56	trace
Water	11·02	12·00	12·70	12·55	10·30
	99·71	100·00	97·80	99·43	100·00

The following analyses from several of the best European localities will enable comparison to be made with those from Cornwall and Devon, viz :

	St. Yrieix.	St. Yrieix.	Seilitz.
Silica	46·80	48·00	58·60
Alumina	37·30	37·00	34·60
Alkalies	2·50	2·05	2·40
Magnesia	trace	—	1·80
Lime	—	—	—
Oxide of iron	—	—	—
Water	13·00	12·95	—
	99·60	100·00	97·40

	St. Tropez.	Meude.	Normandy.
Silica	55·80	63·50	50·00
Alumina	26·00	28·00	25·00
Alkalies	8·20	1·00	2·00
Magnesia	0·50	8·00	0·70
Lime	—	—	5·50
Oxide of iron	1·80	—	8·50
Water	7·20	—	9·50
	99·50	100·50	101·20

The variation of silica in the above analyses of Cornish and Devon clays, ranges from 37·10 to 52·00, and of alumina from 36·20 to 47·00, while that of the foreign clays, as given, ranges from 46·80 to 63·50 of silica, and from 25·00 to 37·30 of alumina, showing the latter to have a much higher mean percentage of silica, and a considerably less proportion of alumina in their composition. There are besides very varying percentages of alkaline ingredients, and of ferric oxides and other impurities, which, in the event of analyses of their clays not being got from and guaranteed by the clay merchants, shows the necessity of their being analysed before being used by potters who aim at certainty and regularity in the composition of their “bodies.”

As has already been pointed out, the true porcelain clays of Cornwall and Devon differ from the pipe and potting clays of the Teignmouth and Poole beds—these latter being “natural deposits,” only requiring drying to fit them for market, and being all inferior in quality, so far at least as suitability for the manufacture of hard porcelain is concerned, to the former. Although the term “deposits” is sometimes loosely applied to the porcelain clays, they are with rare exceptions¹ not deposits at all in the usual acceptation of that term,

¹ Mr. Collins states that these occur only in one or two places in the Hensbarrow district, such as that at Higher Carpella, in St. Stephen's, and at Carloggas, near Foxhole Bridge—the former, in his opinion,

the soft growan from which they are obtained by water action being almost invariably the result of decomposition *in situ* of some species—whatever that may be—of the felspar of disintegrated granite, be that protogene, pegmatite, or some distinct species as yet unnamed, but which cannot correctly even be called “Cornish granite,” as there are hard and durable granites in Cornwall as elsewhere, which are certainly quite distinct from that which furnishes the “growan.”

The disintegrated granite from which, by the decomposition of its felspar, china clay is obtained, is found in many localities in Cornwall, and also in Devon. It occurs, according to Mr. Collins, in areas of irregular form, generally much elongated and extending to an unknown depth, and is found in immense quantities in the western portion of the Hensbarrow range. It is universally associated with quartz, ore, and schorlaceous veins, which sometimes also contain oxide of tin. Many beds of it extend for a distance of a quarter of a mile, half a mile, or even more, in the direction of the veins, while their breadth may be only a few inches, and seldom exceeds one or two fathoms; very wide masses of it are wrought in many places, but these are invariably associated with groups of many parallel veins. Many of the clay mines, or open workings, such as that of the extensive quarry at Carelaze, were originally commenced for the sake of the tin in their numerous schorlaceous veins. The china-clay rock, “carelazite,” occurs most abundantly in that immense open working, and in the neighbourhood of St. Austell, and is most largely worked, as stated in Mr. Quick’s paper, previously referred to, in the parishes of St. Austell, St. Mewan, St. Stephen’s, St. Dennis, St. Ender, Roche, and St. Blazey; and on a smaller scale in the eastern

“resulting from the degradation and re-deposition of the natural clay rock of the higher grounds, and being only one or two fathoms in depth”; and the latter, “simply the mass of decomposed granite, which has bent over by its own weight, so as to occupy a pre-existing valley.”

part of the county at Blisland and St. Breward, near Bodmin; and in the western part, near Helston: and in Devonshire, chiefly at Lee Moor, a part of Dartmoor, near Plymouth. Mr. Collins states that its occurrence is usually indicated to the practised eye by a peculiar depression of the surface, which is not observable where the china-stone rock alone occurs. It is found at all elevations, except the very highest, which, he states, are always composed of hard rock; its hardness being doubtless the cause to which the escape of these towering points from degradation is due. The carelazite resulting from the disintegration of the granite, contains, of course, more or less of its constituent ingredients, except those soluble ones (alkalies, silicates, etc.) which have been carried off by water action during the decomposition of its felspar, and consists of varying proportions of that mineral undecomposed, grains or irregular crystals of quartz, flakes of mica, sometimes a little schorl, and, finally, the completely decomposed felspar, which is ultimately more or less perfectly freed from all the other ingredients by the processes which will now, as briefly as possible, be described from the accounts given by Dr. Boase, Mr. Collins, and others, but which are more descriptive of the operations carried on prior to the great extension of the trade in recent times, and are now confined to the smaller clay works. Dr. Fitton described them (*Annals of Phil.*, vol. ii. p. 348) after a visit to Cornwall in 1807; and Mr. James Quick states, that with the exception of a few modern improvements, they are very similar to the methods pursued for many hundreds of years past in China. But as the principle is the same—however much the *modus operandi* now differs in large works—and sufficiently explains how the clay is separated from the other ingredients associated with it in the carelazite, it is given in preference to a detailed account of the much enlarged and more complex arrangements and apparatus employed in the large works, now so numerous in the clay districts, in which

the production of clay is carried on on a vastly larger scale and by quicker and more efficient processes than those described underneath ; for any adequate description of these space cannot be afforded here, but any of the readers interested in the subject will find full details of the whole in Mr. Collins' *Monograph*.

The first operation is that of removing the vegetable soil and substratum, called by the workmen the *overburden*, which consists of rock débris, sand, and impure discoloured clay. This, according to Dr. Boase, varies in depth from 3 to 5 feet, but, according to Mr. Collins, from 3 to 40 feet. The overburden removed, the clay¹ is worked in "stopes," being dug out progressively, by the aid of picks, in steps, resembling a flight of irregular stairs. The depth of the china-clay pits, as they are called, is various ; but while fifty years ago it seldom exceeded twenty feet, shafts are now sunk to raise the clay from depths of 70 feet or more. The clay, when first raised, has the appearance and consistence of mortar, containing numerous grains of quartz, disseminated throughout in the same manner as in granite. In some parts it is stained of a rusty colour, from the presence of ferruginous veins and embedded portions of schorl and quartz. These are called by the workmen, *weed*, *caple*, and *shell*. These discoloured portions are carefully separated and thrown away, while the rest is conveyed to the floor of the washing-place or "strake," where it is thrown down on an inclined platform. On this a stream of water is made to fall from a height of about 6 feet or more, while the workmen constantly turn over the material with piggles and shovels. By this process a large quantity of "sand" is at once separated and deposited in an oblong trench beneath, from which it is shovelled away continually. As from three to eight tons of sand are produced in getting each ton of clay,

¹ The term "clay" is applied in the clay districts indiscriminately alike to the carclazite and to the clay washed out of it.

its removal in the cheapest possible manner is a matter of great importance. The trench is also inclined, and ends in a covered channel that leads to a series of catch-pits and ponds into which the rest of the clayey material is carried by the running stream. The pits are 5 or 6 feet square, or 8 feet by 4 feet, and 4 feet deep, their sides and bottom (as are those of the ponds also) being lined with cut moorstones, laid in waterproof cement. In the first pit the grosser particles of mica and other undecomposed materials, not retained in the trench, are deposited, and being of a mixed nature are rejected, at the end of each day's work, by an opening, provided for the purpose, at the bottom of the pit. When the water has filled the first pit it overflows into the second, and in like manner into the third, and so on. In the second, and perhaps the third also, the fine mica is deposited, and is often retained and sold at a low price under the name of mica clay. These pits are hence called the "micas." The clay held in suspension by the water, overflows from these into the last pit, where it is partially deposited; and thence into the ponds. These are of the same depth as the pits, but about three times as long and wide, generally about 20 feet long by 12 feet wide. The suspended clay can be procured of greater or less fineness, according to the extent to which it is carried in suspension before its final deposition in the ponds, and when it is finally allowed to settle, the clear supernatant water is run off by plug holes on the side of the pond, the process being carried on till a sufficient deposit of clay is accumulated.

Mr. Henwood, M.E., in a brief memoir, published in the *Report of the Royal Polytechnic Institute, Cornwall*, in 1840, states, that when, either owing to rainy weather or other causes, the clay does not settle in the ponds, it is watered with a solution of alum, to hasten its deposition, and Mr. Stocker states, in a paper read to the same Society, that any saline solution will produce that effect.

It may interest our readers to note here the composition of the carelazite made by mechanical analysis of two fair samples—one, (A) from Great Treviscoe in St. Stephen's, and the other (B) from Cleytane, in St. Enoder, given by Mr. Collins (*Monograph*, p. 28), viz.:—

	A	B
Water.	5·0	5·5
Coarse sand and mica (shell)	67·5	71·5
Fine sand and mica	2·0	2·5
Fine mica and some clay	3·5	3·0
Fine clay	22·0	17·5
	100·0	100·0

The net mean product of clay from the soft growan being, from the above analyses, somewhat less than a fifth, or 20 per cent.

The fine clay, after the water has been as completely as possible run off, remains in the ponds in the state of a fine paste, and is then transferred, generally by hand-barrows, into shallow pans about 40 feet long by 12 to 15 feet wide, and from 14 to 18 inches deep, lined also with cut moorstones. As may be inferred from the much more extensive scale on which operations are now carried on in large works, all the pits, ponds, drying pans, etc., are of much larger measurements than those given above.

Some works are so laid out that the partially consolidated clay has to be pumped into the drying-pans, and Mr. Henwood, in reference to this process, says: "I noticed, with surprise, that clay sufficiently consistent to stand in a heap, will run through a common suction pump worked by hand, though when so drawn it requires to be raked from the pump-head."

When the pans are nearly filled the clay is levelled, and is then left undisturbed till it is nearly dry. The time required for this part of the process depends in a great measure on the state of the weather, and is a tedious process in the damp climate of the west of England, the pans being exposed to the

air—during the summer, four months or less may suffice, whilst at least eight are necessary during the winter—often from September to the following May. When sufficiently dry the clay is cut into cubes or lumps, 9 to 12 inches on the sides, which are then carried to the drying house, an oblong shed, the sides of which are open wooden frames so constructed as to keep out rain, but admitting the free passage of air, and of exposure to the sun in fine weather. The clay when dried is scraped perfectly clean, and is then ready for being sent off for shipment in bulk, or, when requisite, in casks. The scrapings and waste are wheeled back to the “strake” and re-washed.

In 1807, when Dr. Fitton visited Cornwall, he found only seven clay works in operation in the parishes of St. Dennis and St. Stephen's; the largest of which only produced some 300 tons per annum. The consumption and demand for china clay has since then so enormously increased, however, that in the Hensbarrow district alone there are now probably about 100 works, many of the larger ones turning out from 2500 to 8000 or 9000 tons each yearly. Mr. Collins mentions that in 1874 one of the largest works near St. Austell produced 9000 tons, employing thirty men, while many others produced 6000 tons each, employing twenty men. To meet the enormously increased demand—arising not merely from the extension of the pottery trade, but to a large extent also from the various uses to which china clay is now applied in other trades and for other purposes—different methods from those described above became necessary; the one most generally adopted being that in which the clay is raised from pits by the sinking of a shaft to the depth often of 10 or 12 fathoms, and the driving of a level from its bottom to where a rise is put up through the clay to surface, in which a “button hole” ladder is placed, and by which the clay, after being by an ingenious contrivance mixed with water, is conveyed down to the level and along it

to the bottom of the shaft, from which it is pumped to surface or lifted at once high enough to allow of all the subsequent operations—similar, but on a much larger scale, to those above described—being carried out by gravitation.

The other method of working is adopted in cases where the bed of clay is situated on a hillside, with plenty of space below. In that case an adit level is driven into the hillside, or from the valley, to the required depth, and a rise put up as before; with some modification of the launder arrangements the clay in suspension in the water makes its exit in the valley, and is there purified, settled, and dried, as already described—the works being laid out on a lower level than the adit.

In the large works the clay is now finally dried—although by no means to the improvement of its quality—by artificial heat, in a large building called the “dry” (which consists of two parts, the “dry” proper and the “linhay”), which Mr. Collins describes. As brought into the “dry” the clay usually contains about 50 per cent. of water, which is reduced to about 12 or 14 per cent. by the time it is thoroughly dried. To get it into the “linhay” ready for market Mr. Collins estimates its cost at 8s. 6d. or 9s., which with dues, transit, agencies, and sundries, is increased to a total average cost to the clay merchant of about 16s. or 17s.

While most of the large china clay works are now carried on by sinking pits and shafts, open workings are still to be met with, of which the largest and most interesting is that of Carclaze. It has a character of its own, and has been often described; but as many may not have seen it, or a description of it, one by an observant foreigner may interest them.

This gentleman, Alphonse Esquiros, visited it some eighteen years ago, and described it in an account of Cornwall,¹ published by him. In writing of the clay works, he says: “Some of these

¹ *Cornwall and its Coasts*, by Alphonse Esquiros, Esq., author of *English at Home*. Chapman and Hall, London, 1865.

works are very interesting, and employ a large number of persons—men, women, and children. The women have white bonnets, white sleeves, and white aprons, and it is curious to see them carrying to the surrounding hills a clay whiter still, which they artistically expose to the sun beams. One of the most curious of the mines is that of Carclaze, two or three miles from St. Austell, a small town with a fine old church. A road runs to a large common all covered with furze and gorse. As the bushes were studded with golden flowers, I did not complain of the sterility of the soil; and, besides, the sea could be seen in all its grandeur at a certain distance. All at once an abyss opens in the gloomy common, before which you halt in stupefaction. The origin of this prodigious excavation, which is at least a mile in circumference, and more than 150 feet in depth (and is probably much larger and deeper now), “and has been attributed by the ignorant to the intervention of Satan, by the learned to the Romans or the Anglo-Saxons. It is not a mine properly so called, but an open quarry; the workmen are ‘streamers,’ that is to say, men who obtain tin by washing the deposits from the disintegration of the rocks. The interior of this abyss, whose greyish whiteness contrasts with the colour of the common and the brown surface of the moors that surround it, displays masses of granite decomposed by certain influences which are not yet thoroughly known.” After a description of the tin workings, he proceeds: “In the same excavation, but on the other side of the quarry, and facing the tin workings, a torrent, at first yellow, but which soon changes its colour and becomes of a milky white, falls over projecting rocks. Men armed with picks feed this torrent, by casting into it lumps of white earth. After running thus to the bottom of the abyss, which it crosses at one bound, the stream suddenly disappears under an arch. You might suppose it lost, but it can be easily found again; to do so, it is only necessary to go five or six hundred yards along the common and find a fresh scene of

operations. Here the white stream is received in reservoirs or cisterns. The milky fluid, by remaining still, deposits at the bottom of these cisterns a sort of cream, above which the water is perfectly limpid and blue. The action of the wind and sun is sufficient to evaporate the water in a few months." (Mr. Esquiros, however, has overlooked the running off of the supernatant water.) "The white clay is then cut out with spades and is carried to open sheds to dry; it there hardens and forms the matter used in making china."

Carelaze mine is now chiefly wrought for china clay, but, Mr. Collins says, still yields notable quantities of tin. It was in full work as a tin mine in the reign of Henry VII. Its area was computed by Mr. Henwood in 1843 at 5 acres. According to Mr. R. Symons, of Truro, who surveyed it five or six years ago, it was then 13 acres. There is an interesting account of this mine in the *Intellectual Observer*,¹ written by Professor Church, who states that it was not till towards the close of the last century that the earth, or soft rock, of which the whole place seems to consist, was recognised as china clay. He mentions that the supernatant water in the tanks, after the clay has all settled, is of a beautiful greenish-blue colour. Referring to the mineral substances in the native claystone, he also says, that a yellow green talcose mineral is the most important of these. He refers to the complete absence of all the usual signs of mining operations as you approach Carelaze, and says that, as you cross the moor, you are, without knowing it, close to the mine, which is unseen till you reach the grassy edge of the great pit. It is approached from St. Austell by a hilly, deep, and winding lane, which passes close by the west end of St. Austell Church, and brings you out upon the moor; bright, and usually breezy too, in summer, but very drear in winter. White roads intersect the moor, along which Professor Church says, pass continually towards the sea, three miles distant,

¹ *Intellectual Observer*, vol. ii. p. 401. Groombridge, London, 1869.

waggon and carts laden with square blocks of a substance of dazzling whiteness. His description of Carclaze and what he saw there will interest anyone who may refer to it, especially as it is accompanied with a coloured view of the moor and the mine.

CHAPTER XI

CHINESE KAOLIN—HISTORY AND COMPOSITION

IN treating of Chinese kaolin, the writer is sensible of how very imperfect our knowledge still is regarding the materials used by the Chinese in the manufacture of their unrivalled porcelain. From the written annals of Feouleang, a city belonging to the same district of the Empire as King te-chin—the great seat of the porcelain manufactories—it appears that the date of the origin of the art of making porcelain is unknown, but it is stated therein that from a date answering to A.D. 442, the latter city had enjoyed the honour of supplying the imperial city with porcelain, and the invention of the art must have occurred at a much earlier period. It is stated by Julien,¹ that its manufacture was commenced in China in the district of Sin-p'ing (province of Ho nan), under the dynasty of Han, some time between B.C. 185 and A.D. 87; and that as early as A.D. 600, porcelain was in common use throughout the country, and consequently the manufacture must, even then, have been on an extensive scale.

In the face of such facts as these, from which it may be safely assumed that the manufacture of porcelain has been carried on in China for somewhere about 2000 years (although some writers question this, and restrict the period of its manufacture to 1500 and even to 1000 years), it certainly does seem remarkable that we still owe nearly all our knowledge regard-

¹ *Histoire et Fabrication de la Porcelaine Chinoise ; Ouvrage Traduit du Chinois, par M. Stanislaus Julien.* Paris, 1856. Translator's Preface, p. 20.

ing the materials used by the Chinese potters to very imperfect information obtained by one or two Europeans, who, from want of all practical knowledge of the art of pottery, and from their ignorance of its technicalities, were incompetent and unable—even had greater facilities been at their command for obtaining them—to furnish such reliable details as might have enabled our manufacturers ere this to rival the porcelain of the Chinese. Some scanty information may be found in the account given by Marco Polo,¹ the celebrated Venetian traveller, who, in the thirteenth century, resided for some time in China, and saw at Kin-sai the manufacture of porcelain. He states that the manufacture was carried on to a vast extent, and adduces as proof of its cheapness, even at that early date, that eight porcelain cups could be purchased for a Venetian groat. He mentions the fact of the prepared clay—which in China is first kneaded in pits by the feet of the workmen, and then by hand in smaller quantities—being left exposed to atmospheric influences for many years. This practice is one to which Chinese potters evidently attach much importance, the prepared clay being frequently kept for fifteen or twenty years; Dr. Watson (in his *Chemical Essays* already quoted) says, for “twenty or thirty years” before being used. The longer it is kept the more valuable it is considered, and instances are not uncommon of provident parents preparing sufficient clay to last their sons for their lifetime. In an article on “China and Earthenware,” in *The Pottery Gazette* for May 1883, it is stated that instances are not unfrequent of a Chinese potter making his wares of clay first prepared by his grandfather.

This practice of a lengthened mellowing of the slip is one which it would be well if our manufacturers could follow to a greater extent than is customary in Europe, as no amount of pressing, kneading, and slapping, or other mechanical processes, can possibly solidify it so perfectly as that of leaving it for a

¹ *Marsden's Translation*, 4th edition.

lengthened period to the solidifying and mellowing effects of atmospheric influences, the longer exposed to which the more free of air-bubbles, and the more homogeneous the dried slip, becomes and the more perfect, of course, the wares made from it.

As mentioned by another contributor to *The Pottery Gazette*,¹ the Museum of the Royal Society had, previous to Cookworthy's discoveries of Cornish china clay and stone, specimens of the Chinese kaolin and petuntze, which had been presented to it by Dr. Sherard, a traveller in China, and which, the above contributor states, had suggested to Cookworthy the examination of the granier (or granen) of Cornwall for similar materials. He further states that, according to Cookworthy, the felspar, which in the white granite of Cornwall is combined with quartz and mica, supplies the most essential component of Oriental china. In the same article, the writer mentions the discovery by Mr. Ryan, F.S.A., "in a deserted lead mine, of felspar in the two states, which the Chinese call kaolin and petuntze, or rock and clay." When and where (although the locality was probably Cornwall) is not stated, but in an article already quoted, the writer of it gives the date of Mr. Ryan's discovery as 1834, and states that the clay possessed all the essential qualities of the Japan kaolin. Both of these materials were used by Mr. Josiah Spode for many years.

The writer called lately at the Royal Society's rooms, in the hope of seeing the specimens above referred to, but was informed by the secretary that the whole contents of the museum had, many years ago, been presented to the British Museum. On going there, Mr. Fletcher, the curator of the mineralogical department, informed him that the presentation by the Royal Society must have been before his appointment, as he had never heard of it; but he obligingly offered to search the private drawers under the cases containing the kaolins and other silicates of alumina, and in one of them we found a tray

¹ "Progress of Pottery Manufacture," No. II. April 1883, p. 317.

with a specimen of china clay, below which there is an old faded scrap of paper, on which is written in ink, quite brown from age, not "kaolin," but "petuntze"—this very probably being one of the specimens presented to the Royal Society by Dr. Sherard, although, of course, the label may have got misplaced.

In the *Catalogue of Specimens in the Museum of Practical Geology*, which has been several times already quoted, it is said (p. 9) that it is probable that the general composition of the artificially prepared clays employed by the Chinese for their porcelain has long remained the same, so that by an examination of those now employed we may obtain a fair knowledge of those formerly used. This was written nearly twenty years ago, but to this day, notwithstanding the Chinese Empire having been since, and during most of that time accessible everywhere to Europeans, who have penetrated to its most remote parts, we have still, so far as the writer can ascertain, no reliable information whatever regarding the ingredients of Chinese porcelain and their composition later than the very superficial and imperfect information furnished by the Jesuit father, Francis Xavier D'Entrecolles, who, early in the eighteenth century, was residing as a missionary at King-te-chin. In the treatise referred to in the last chapter, and from which the writer quotes some interesting details in this article, the author states that D'Entrecolles contrived to elude the jealous vigilance so generally practised then towards strangers in that country, and that he not only obtained specimens of the earths used in the composition of their porcelain bodies, but also acquired some knowledge of the processes employed in its manufacture at King-te chin. He states also that a very circumstantial letter was written by the learned father on the subject, which was published by Grosier in his general description of the Chinese Empire, but, owing to the want of practical knowledge on the part of D'Entrecolles, his descriptions "proved so defective in many particulars as to afford little or no

assistance towards a knowledge of the ingredients used for Chinese porcelain"; and yet, defective as his descriptions are, they have been the only ones available to potters and students of the subject during the 170 years or so which have elapsed since they were published—during which time they have been repeatedly quoted by numerous writers as if they were full accounts and perfectly reliable. In the *Catalogue of Specimens in the Museum of Practical Geology* (p. 9), it is said that, according to the Père d'Entrecolles, the chief ingredients of Chinese porcelain are kaolin and petuntze; and, it is added, it is generally believed that the former is decomposed felspar, but the definition of the latter is involved in more difficulty. *Po-tun* signifies a white paste, and the suffix *tze* is merely a diminutive applied to the material when made into the usual form of small cakes or bricks (those of a yellow earth being called *huan-tun-tze*, and those of a red material *hon-tun-tze*); and it appears, indeed, that several substances used in the manufacture are prepared in the form of white tablets, and pass under the common name of *petuntze*, which term only indicates colour and size, and nothing whatever of their composition. By D'Entrecolles, however, it was assumed to be restricted to the fusible ingredient of the porcelain paste, and therefore it has generally been considered to denote a substance resembling our Cornish china stone (although no analysis of it, with the exception of one of a Japanese porcelain-stone given by Janviers—and which may or may not be identical with petuntze—so far as the writer has seen, has ever been published), which is an aggregate of felspar, usually more or less decomposed, and quartz, commonly associated with a feldose or alkaline substance—in fact, a disintegrated granitic rock, protogene or pegmatite; and in a footnote (p. 9) it is said that "it is probable that some confusion has arisen in the application of the terms 'kaolin' and 'petuntze,' and that they are not used in the same sense as that in which they are employed in China."

Other quotations from various authors could be given, to show, not only that some uncertainty exists in reference to this material, petuntze, but even that the opposite of the generally received opinion about it is held by some, as for instance in *Dodd's Dictionary*,¹ where it is said that a "peculiar kind of granite called Cornish stone was, somewhere about a century ago or more, found to be almost identical with the kaolin, or porcelain earth employed by the Chinese. This," it is added, "was a great step towards the naturalisation of the manufacture in this country." In this passage china stone is identified, not with the petuntze, but with kaolin.

The communications of D'Entrecolles excited much interest at the time of their publication, and led to the celebrated Reaumur undertaking a series of investigations with the object of ascertaining in what the superiority of Chinese porcelain consisted. He procured specimens of Chinese, Saxon, and French porcelain, which he broke, and found the internal structure of both the two former to be compact, smooth, and shining, while that of the French was less close and fine, and without lustre, and its grain resembling crystalline sugar. He next tested them by exposure to such extreme heat in a crucible that all the European specimens were melted, while the Chinese remained unaltered. This most essential difference led Reaumur to the discovery of the true nature of porcelain, which is a semi-vitrified compound, in which one portion remains infusible at an extreme heat, while the other portion vitrifies at that heat, and, enveloping the infusible part, produces that smoothness, density, whiteness, and, in the case of china-ware, transparency, which, with a fine texture of the glaze (resembling the lustre of velvet rather than of satin), is characteristic of the finest descriptions of porcelain. Macquer, however, in his *Chemical Dictionary*, questions the correctness of Reaumur's conclusions, and it is probable that the Saxon specimens he

¹ *Dodd's Dictionary of Manufactures*, article on "Porcelain."

experimented upon were not made of the best materials; Macquer asserting that the clay and other ingredients of the porcelain of Saxony are similar to those employed by the Chinese, one portion being absolutely infusible: and in this he is corroborated by the writer already quoted,¹ who says that "the Dresden, or Saxon, china has some qualities which render it decidedly superior to the Oriental"; and after describing its materials and texture, adds, that "it is not fusible by any heat employed in firing." This may be so, when it is only subjected to the extremest heat of European kilns; but the heat to which Chinese porcelain is usually subjected is so much greater, that it is said that some of the materials employed in the Chinese glazes cannot be vitrified at a lower temperature than would suffice to fuse granite. The Chinese porcelain glaze is much superior to any used in European potteries, and requires such extreme heat for its fusion—the object aimed at being to render it perfectly impermeable to moisture from the ware in firing, which is necessary, owing to the Chinese subjecting the greatest part of their porcelain to only one firing, previous to which the ware is dried sufficiently in the air to prepare it for glazing. This plan, superseding the separate biscuit and glost firing of our potters, must secure a great saving in time and cost of firing, besides in that of breakage and other losses in the kilns; but it is unattainable by our porcelain manufacturers, owing, if for no other cause, to the inferior refractories of the fire clays they use for saggers, a reference to which was made by the writer in his article on "Fire Clay," in *The Pottery Gazette* for December 1883.

Reaumur, in his experiments with the specimens of kaolin and petuntze received from China, reported to the Academy of Science, that while the former gave no indication of fusion in a porcelain furnace, the other was fused without any addition of fluxing materials; but owing to the want of authentic

¹ "China and Earthenware," *The Pottery Gazette*, May 1883, p. 411.

analysis of both these materials there is evidently a great deficiency of reliable information as to their exact composition. The writer on "China and Earthenware" in *The Pottery Gazette*, already quoted, says that petuntze is obtained by abrasion and from "fragments of a rocky mineral, of which the greenish is the best—now proved to be felspar, with a small portion of protosulphate of iron," and he then proceeds to indicate, rather than describe, the processes by which it is reduced to an impalpable powder, and formed into cakes, in size and thickness much like floor tiles. He states, however, that kaolin also is "obviously felspar found in beds reduced by atmospheric action to the state of clay; and that it is so named from being found in a state, by nature, almost ready for the manufacturer." That this is not the origin of its name is well known, it being derived from its original source, as stated below. The same writer, referring to china and porcelain as well as to earthenware, says that its "hardness, infusibility, and unalterability require the presence of flint"; and again, "silica, when pure, is transparent, and when calcined loses much of its adhesive quality, and even in the pulverised state communicates to the ware hardness, firmness, and unalteration by firing." Now, as evidencing the confusion of ideas in respect to the composition of the ingredients of porcelain, and of kaolin and petuntze, respectively, the author of the *Treatise on Porcelain*, quoted in the last chapter, says: "It is the kaolin which, although much softer than the petuntze when taken from the quarry, gives strength and body to the porcelain, and consequently this, or some substitute possessing the same quality, forms an indispensable ingredient in its composition." He adds that "it is related that some Europeans, having privately obtained some blocks of petuntze in China and conveyed them to their own country, vainly endeavoured to convert them into porcelain: which, becoming known to some Chinese manufacturers, they deridingly remarked, 'That certainly the

Europeans must be a wonderful people, to go about to make a body, whose 'flesh' was to sustain itself without 'bones'" (p. 109). This story appears somewhat apocryphal on the face of it, but, if true, does it not rather indicate that petuntze is at all events not identical with china stone, which can by itself make a passable body; and that more probably kaolin was the material—the attempt to make a porcelain of which, without a siliceous ingredient, excited the mirth of the Chinese manufacturers? The simile they used (if they did use it) was not a very appropriate one, but certainly our china clay would be more appropriately called the "flesh," and flint the "bones" of porcelain, than would the reversal of these terms. The same author states that kaolin is found intermixed with particles of a shining substance resembling mica (p. 105), and again (p. 109) that it is known from the particles of mica which it contains, to have its origin in felspar, or (? of) graphic granite (pegmatite). Those two rocks, felspar and pegmatite, are not at all similar; and it will be shown that kaolin is not derived from a granitic rock at all.

It has been stated by the Baron von Richtofen¹ that it seems uncertain now whether the Chinese use, in making porcelain, what we call kaolin, for the mineral they obtain from Kau-ling, the locality from which their kaolin was originally got, and from which it has been named, is a greenish rock (Yeou-ko), as hard as felspar, which they reduce to a fine powder by stamping and other processes, after which it is moulded into small bricks. He adds, "that formerly the best quality came from Kau-ling, but that this place has lost its prestige for centuries; nevertheless the Chinese still use the term for the best of this material, from whatever locality it is got." Unfortunately the Baron gives no information as to the localities from which the factories (500 or more in number at the time D'Entrecolles resided there) at King-te chin now

¹ *American Journal of Science*, March 1871, p. 179.

obtain their supplies. He states further, "that the application of that name, by Berzilius, to porcelain earth, was made on the erroneous supposition that the white earth he received from a member of the embassy occurred naturally in this state. *The same kind of material is called petuntze.*" Its composition is given by Janvier,¹ from an analysis by Ebelman and Salvétat, as—

Silica	75·09
Alumina	14·02
Magnesia	traces
Potash	2·09
Soda	3·05
Ferric oxide	0·08
Lime	0·05
Ox. manganese	0·03
Water, combined	2·03
	96·44

In the work of Stanislaus Julien, above quoted, there is an appendix containing a short "Memoire sur la Porcelaine du Japon," by Dr. J. Hoffman, describing the porcelain quarries of Japan, in which he states that the "terre blanche," or "terre à porcelaine du Japon," which is used for the fabrication of porcelain, comes from the mountain Idzumi Yama, and is white, but as hard as rock, and has to be broken with hammers, and pulverised in mills. Its composition as given by Janvier, from an analysis by Malaquti, is—

Silica	75·09
Alumina	20·00
Potash	3·05
Lime	0·06
	98·20

¹ *Practical Ceramics*, by C. A. Janvier, p. 34. Chatto & Windus, London, 1880.

From the large percentage of silica and the percentages of alkaline ingredients in these two analyses, it may be assumed that these are the analyses of very siliceous felspars or petrosilexes, rather than of the porcelain clays obtained from them, of which they are given as analyses; but the more the matter is looked into, the more uncertainty appears attached to it, and it is very much to be regretted that some persevering attempt has not been made ere now, either by the Chamber of Commerce in the Potteries, or by the authorities of the Museum of Practical Geology, London, to obtain both from China and Japan certified specimens of the various minerals which are used as ingredients of their porcelain wares, and of which reliable analyses could then be had for comparison by our porcelain manufacturers, with those of our Cornish and Devon china clay and stone.

CHAPTER XII

CHINESE KAOLIN—PETUNTZE

IN the *Treatise on Porcelain*, quoted in the last chapter, and already referred to, the author states (p. 105) that the Chinese kaolin and petuntze “are found in mines or quarries situated between twenty and thirty leagues from King-te-chin, to which they are brought in small vessels, which are continually passing up and down the river of Jao-tcheou for that purpose,” and he further states “that the hard blocks of petuntze are cut from the quarry in the form and about the size of our bricks, and are brought in this state to King-te-chin.”¹

He describes the methods by which the petuntze is reduced to a sediment and dried in moulds and afterwards cut into square pieces, which are sold by the hundred to the porcelain makers. He states also that “similar processes are followed in the preparation of the kaolin, but this substance being much less hard than petuntze, less labour is required for its performance.” In this account the kaolin and petuntze—which are the prepared materials, and appear to be prepared for use, not by the porcelain manufacturers, but by parties who make their preparation a special business—are evidently confounded with the rock minerals from which they are produced. The author

¹ Although the writer has followed Janviers and other recent authorities hitherto in the spelling of this name, he may as well mention, that in a new map just issued by the China Inland Mission, it is spelt “King-te-ching.”

further states that two other substances, described as oil (a Chinese term for an alkaline preparation of lime, but which contains no oil) and varnish, are used in the manufacture of porcelain—one of these is “a combination of petuntze (?petrosilex) with another substance,” the name and composition of which is not given, but “to each one hundred pounds of which, after being reduced to a creamy condition, one pound of a mineral called ‘she kao,’ or ‘chy kao,’ which is a kind of gypsum, is added.” The other is “a thin paste of lime and potash obtained from quicklime and fern ashes,” the latter fluxing the lime, and, “to dissolve this mixture she-kao is also added in the same proportion as to the other. To the agency of this oil of lime the Chinese manufacturers attribute all the lustrous appearance of their porcelain. In mixing these two varnishes together, one measure of the oil of lime is added to ten measures of that of petuntze.” The same author states that since the time when D’Entrecolles communicated his observations on the porcelain manufacture in China, the potters there have discovered a new mineral which they can advantageously use in the manufacture of porcelain. It is described by him as a species of chalky (or calcareous) stone, “which bears some outward resemblance to soap, and is declared to possess considerable medicinal virtues. It is called ‘hoa-che’; and when used instead of kaolin, the result is a porcelain of very fine grain, and much better qualified for receiving colours, but more brittle and far dearer in cost than the common porcelain, the price of hoa-che being three times that of kaolin.” The hoa-che is very probably a species of steatite, a silicate of magnesia, and which is capable of being made into porcelain without any admixture of other materials, as the author affirms can be done with hoa-che.

Now it would naturally be expected, that, having a Museum of Practical Geology here, which has been in existence for

many years, anyone desirous of learning something of the clays and other ingredients employed by the Chinese and Japanese in the manufacture of their porcelain, would find specimens of all their materials there, with analyses of them attached. Strange however as it may appear, it is not the less a fact, that all our Government Technological Museum can show is a few small specimens, not obtained through official agency, but which have been picked off the materials being conveyed by the vessels from the quarries to the neighbourhood of King-te-chin, or from the carts conveying them from the vessels to the works, by someone who probably was unable to tell correctly what the several specimens really were. These, such as they are, have been forwarded to the Museum by W. Lockhart, Esq., to whom therefore all the scanty means at present available for any practical knowledge of Oriental porcelain ingredients are due; but even of these no analyses have yet been published. The writer, by the courtesy of Mr. Rudler, curator of the Museum, has lately been allowed to inspect these specimens—of which, however, little can be made without analyses. Amongst them is a small specimen about $1\frac{1}{2}$ -inch long, by $1\frac{1}{4}$ broad and $\frac{1}{2}$ of an inch in thickness, which is a hard mineral of a greenish-yellow tint, and labelled as the mineral from which the Chinese kaolin is produced; whether it is identical with the mineral “Yeou-ko,” of which Janvier (in his *Practical Keramics*, p. 34) gives the analysis quoted on p. 96, *supra*, the writer has not yet been able to ascertain, but there is no doubt that it is a petrosilex and not a granitoid mineral such as Cornish china clay is obtained from. Janvier, from the best information, says (p. 149), it may now be inferred, “that most Chinese porcelains have a strictly petro-siliceous basis, and that the term kaolin is applied by the Chinese to a washed, pulverised petrosilex, and not to the clay we call kaolin”; and therefore, from this and the various quotations already given from other sources, it would certainly, the writer

presumes to think, be an advantage gained to the nomenclature of porcelain manufacture, if the term kaolin was dropped as a name for our china clay, and that of carelazite substituted, as proposed by Mr. Collins.

As may be inferred from the foregoing remarks, there are few available sources for obtaining reliable analyses of the ingredients of Chinese porcelain, but leaving over in meantime any that it may be possible to obtain of its other ingredients, the writer will now give all the analyses of Chinese kaolin, which have come under his notice. Should any readers be in possession of others, or be able to refer to sources of obtaining them, they will confer a favour by sending them, under cover, to the publishers.

The author of the *Treatise on Porcelain Manufacture* states (p. 109), that the kaolin quarries of China are similar to the mines of Alençon, and St. Yrieix near Limoges, where a similar porcelain earth is found—all of them having a superstratum of red, friable, micaceous rock, of the texture of gneiss. From his statement, however, it is really difficult to determine when he is referring to the clay, and when to the rock it is obtained from. He gives no analysis of the kaolin, but states its composition to be—

Silica	52.00
Alumina	42.00
Oxide of iron	0.33
	94.33

but the writer believes this is not likely to be correct—the percentage of alumina being much in excess of the percentages given in all the other analyses.

In Bloxam's *Chemistry*, p. 285, it is stated that the Chinese kaolin contains “a considerable portion of free silica” (which is doubtful), “along with variable percentages of lime, magnesia,

and oxide of iron," and the following analysis of it is given, viz:—

Silica	50.5
Alumina	33.7
Potash and soda	1.9
Oxide of iron	1.8
Magnesia	0.8
Water and loss	11.3
	100.0

In Ure's *Dictionary of Arts*, vol. iv. p. 512, a similar analysis is given of kaolin from Si-king, in China—evidently of the same clay as the foregoing, as the analyses are exactly alike. Neither of these gives the source from which they obtained their analysis, or by whom it was made.

In the same dictionary, however (vol. i. p. 204), is given the following analyses (investigated by W. Kulman) of three qualities of kaolin from Kiu-kiang, in the form of bricks dried at 110° C., and of course not deprived of their constituent water:—

	No. 1.	No. 2.	No. 3.
Silica	50.637	52.208	51.210
Alumina	32.737	31.997	33.150
Oxide of iron	0.955	0.712	0.709
Ferrous oxide	1.690	1.911	1.936
Ox. manganese	0.827	0.540	0.843
Lime	0.501	0.464	0.456
Magnesia	0.268	0.273	0.284
Potash	2.520	1.560	1.403
Soda	traces	0.970	0.992
Water	10.011	9.499	9.500
	100.146	100.134	100.483

Lyell¹ gives the undernoted analysis quoted from Phillips'

¹ *The Students' Elements of Geology*, by Sir Charles Lyell, 2nd edition, 1874.

Introduction to Mineralogy, of Kaolin from King-tah, China,
viz :—

Silica	71.15
Alumina	15.86
Lime	1.92
Water	6.73
	95.66

And it is probable that this analysis may much more correctly represent the character of much of the Chinese kaolin than the first one given, because their porcelain bodies contain a much larger proportion of silica and less alumina than does English porcelain, both their kaolin and petuntze being obtained from very siliceous rocks.

It will be seen from a comparison of the above analyses of kaolins from Kiu-kiang that they have larger percentages of silica than the Cornish and Devon china clays, of which analyses have been given; while, on the other hand, all the analyses of Chinese kaolins given above, with the exception of the last, have less percentages of silica than several of the china clays of France and Saxony, analyses of which have been given.

Janvier says that the “best Chinese porcelains appear much the same in texture as the European hard porcelains, differing, however, in the composition of both the paste and glaze,” and further, that, “having a much greater proportion of silica, they are more fusible than the fine European pastes, which are very aluminous, and consequently very hard.” A comparison of the analyses, however, of their kaolin, with those of the Continental clays, shows, as has just been stated, that at least some of the latter have a considerably larger percentage of silica than the Chinese kaolin—unless the analysis from Phillips’ *Mineralogy* is to be taken as their standard; and that the Chinese porcelain, if much more

siliceous than the European, derives its excess of silica probably from its petuntze ingredient.

Janvier proceeds to say that the Chinese paste, and still more the glaze, will melt in the greatest heat of the European kiln. This and the preceding statement are so diametrically opposed to the statements the writer quoted from Reaumur, and from other sources, that, not having himself much practical knowledge of porcelain manufacture, he cannot offer any opinion of his own as to which is correct; but would urge the diversity of statements in the matter as a proof of the desirability of specimens of the Chinese and Japanese porcelain materials, and of their porcelain, with accompanying analyses, being obtained and placed in the Jermyn Street Museum for the benefit of the trade.

The writer has been unable to find any reliable information regarding the ingredients of Japanese porcelain except from Janvier, who, in *Practical Keramics*, already quoted, gives the following analysis of "Terre d' Porcelaine du Japon" by Malaguti, viz. :—

Silica	75.09
Alumina	20.00
Potash	3.05
Fluorvine	0.06
	98.20

and mentions quartz, felsite (or petrosilex), felspar, and a peculiar porcelain stone from Arita, as other ingredients of Japanese porcelain. Janvier says that the Japanese have surpassed their teachers, the Chinese, and are now the best potters and decorators in the world; in delicacy of finish and in perfection and harmony of colour they are unsurpassed. According to their own authorities, they derived the art of porcelain manufacture from the Chinese. In the sixteenth century, porcelain was first made at Hizen under the direction

of Gorodayu Shonsui, who went to China to learn the art, while, about the same time, several porcelain makers were brought over from the Corea by Prince Nabesshima Naoshige. The art had been, some time previously, introduced into the Corea from China, and had there attained such perfection, that both China and Japan acknowledge their obligations to that country. Genuine Corean porcelain has a remarkably pure white surface, and is very thin and delicate. The Chinese value it highly, but no porcelain is now made in Corea (Janvier, p. 163).

According to the same writer, the Japanese paste is more fusible than the Chinese, and their porcelain is very translucent, owing to the fact that it contains more silica and less alumina than the Chinese or any other hard porcelain. It is also of a purer white body than the Chinese; the best qualities are very delicate, and are very carefully finished off. Hizen, Owari, Kioto, Tokio, and Kaga, are the principal places for porcelain in Japan.

The following are two other washed ingredients of Japanese porcelain, called "Shiro-chu-ehi" and "Sakaime-chu-ehi" respectively, analysed by Wurtz, which are given by Janvier, viz. :—

Silica	80·920	81·141
Alumina	15·822	14·542
Magnesia	0·100	0·242
Potash	0·530	0·999
Soda	1·530	1·789
Iron	0·932	1·060
Fluorine	0·152	0·195
Ox. manganese	0·014	0·031
	100·000	99·999

What these are, the writer cannot determine, but Janvier states (p. 148) that "according to careful investigations made

at the time of the American Centennial Exhibition the finest Japanese porcelain seems to be made without the use of any kaolin at all, or of any equivalent therefor, being compounded as to its body solely of petuntze-like, or petro-siliceous materials," and suggests that similar materials might be found in the West to enable our porcelain manufacturers to rival the Oriental. Janvier is of opinion that the European china clay porcelain seems to be a new invention which must be classed by itself as a china clay (carelazite) body, whilst the Japanese and Chinese porcelains should be classed as felspar or petrosilex bodies, as might be found to be most correct; certainly, at present, little is positively known as to their composition. The Japanese, in their exhibit in Paris (1878), stated that *no kaolin was used in their porcelain*.

CHAPTER XIII

EUROPEAN AND CHINESE CLAYS COMPARED

FROM the statements quoted from various writers in this work it is obvious that some uncertainty at least exists, as to the absolute identity of our Cornish china clay (carelazite) with the Chinese kaolin; but as several authorities state that they are identical, and that any uncertainty that exists as to the composition of the ingredients of Chinese porcelain, relates more to the petuntze—assumed generally to be the fusible or fluxing ingredient of the body—than to the infusible clay ingredient, the writer will not discuss this question further until he treats of the Cornish china stone, when the whole question may be more satisfactorily reviewed.

Amongst other writers on kaolin, a prominent place must be given to Messrs. Johnson and Blake, who, after considerable research, and the examination, by aid of the microscope and otherwise, of a variety of plastic clays, found that many of them, including porcelain and pipe clays, and also some fire clays, possess certain chemical and physical properties which admit of precise definition, and that kaolin (china clay) possesses these most commonly and abundantly. These, and specially the latter, they found largely to consist of pearly hexagonal plates of the prismatic or trimetric system; and in a joint article in the *American Journal of Science*,¹ they proposed to rank all such as a distinct and new mineral species (of the genus *aluminum*), under the name of *kaolinite*,

¹ "On Kaolinite and Pholerite," by S. W. Johnson and John M. Blake, *American Journal of Science*, N.S., vol. xliii. 1867.

and their proposal has been adopted in the mineralogical department of the new Natural History Museum, South Kensington.

In the article referred to, Messrs. Johnson and Blake say, that kaolin is described by nearly all writers as an opaque amorphous substance. Some have mentioned it as containing minute transparent plates, but have supposed them to be mica or other admixture. They had examined "twenty specimens of kaolin, pipe, and fire clays—origin of most unknown. In all of them were found greater or less proportions of transparent plates, and in most of them these plates are abundant—evidently constituting the bulk of the substance." They further state that the "porcelain clay from Deindorf, Bavaria, is perhaps the most finely divided of all the white clays studied. When dusted on a glass slide it appears to consist chiefly of masses of a white substance that are opaque, or nearly so, in transmitted light, but, when fully illuminated above and below, they have the translucent aspect of snow in the lump. Interposed among these masses may be seen extremely minute and transparent plates of irregularly rounded outline. When placed in water, these masses are almost entirely resolved into similar transparent plates, most of which are not more than .0001 of an inch in breadth. This description applies also to all the finer plastic clays."

In reading Messrs. Johnson and Blake's article, the writer was struck with the fact that those gentlemen had apparently not been able to procure and examine any specimen of the Chinese kaolin, however carefully they may have examined the porcelain and other clays of Europe and America; and yet they take for granted that the common belief, founded on the information furnished by Francis Xavier d'Entrecolles, nearly 200 years ago, is correct; and actually, on that mere supposition, they have proceeded to apply the Chinese term to the European and American clays, which differ both in

composition and origin from those of China and Japan. It is certainly a very unusual procedure so to fix scientific nomenclature on a doubtful basis, and it is to similar assumptions that all the uncertainty prevalent on the subject is due.

Messrs. Johnson and Blake quote the chemical formula first deduced by Forchhammer, from the analyses of a number of porcelain clays, viz., 4 Si, 3 Al_2O_3 , 6 H, or 2 Si, Al_2O_3 , 2 H, and they give the following analyses from that chemist of the porcelain clays on which he founds it, viz. :—

	From Richmond, Va.	From Zeisigwald, Sax.	From Altenberg, Sax.	From Freiberg, Sax.
Silica . . .	48·56	49·91	45·63	47·74
Alumina. . .	35·61	35·23	39·89	39·48
Water . . .	12·88	14·86	13·70	14·07
Impurities . .	2·95	0·00	0·60	0·00
	100·00	100·00	99·82	101·29

And they mention that they “found more than thirty analyses of clays, kaolins, and steinmarks, which obviously agree with the formula above given of crystalline kaolinite.” They also state, that the first mention of a crystalline substance with the composition of Forchhammer’s kaolin found by them, was “by Wöhler, who describes, under the name of steinmark (lithomarge—a variety of china clay), a pale, yellow, coherent mass, which is converted by dilute hydrochloric acid, with solution of a little oxide of iron, into a white shining powder. With the help of a lense, Wöhler found it to consist of shining laminae, which, when magnified 200 diameters, were seen to be transparent, and to consist in part of rhomboidal plates. The mass had an earthy fracture which assumed lustre by rubbing, an unctuous feel, and adhered strongly to the tongue.”

Messrs. Johnson and Blake also give an analysis of a clay from Schneckenstein, Saxony, by Professor W. S. Clark, of Amherst College, as follows, viz. : — Silica 46·76, alumina 35·59, water 13·42, impurities 0·94 = 96·71 — sp. gr. 2·6 ; and mention that “this required to be acted on by hot concentrated hydrochloric acid for some time before falling to a white powder. Microscopical examination showed its close physical resemblance to kaolinite. It consists of plates and bundles of plates, the largest being ·0001 of an inch, or less, in breadth, and, when sufficiently magnified, showing a great similarity to the kaolinite from Summit Hill, Pa., U.S.”

From the investigations of Messrs. Johnson and Blake, it may be taken that the basis of many of the china and other plastic clays is a soft, white, transparent, infusible substance, chiefly composed of very minute, flexible, hexagonal plates or laminae, crystallised in forms probably belonging to the trimetric system. Its sp. gr. 2·6 ; lustre, pearly ; insoluble in dilute hydrochloric acid ; in most of its forms difficultly decomposed by hot concentrated hydrochloric acid, but resolvable by hot sulphuric acid, and dissolving completely in strong solutions of caustic alkalies ; and in chemical composition agreeing with the formula deduced by Forchhammer, from his analyses of various porcelain clays, as given above.

CHAPTER XIV

SOURCES OF IRISH PORCELAIN CLAYS

HAVING now pretty well exhausted the subject of these articles on clays; having mentioned the various varieties of clay, especially those in which some readers are more especially interested; having described their chemical composition and qualities, their origin and mode of occurrence in Cornwall and Devonshire, and also in various European localities; having also pointed out the difference between the pipe and potting clays of Devon and Dorset shires, naturally deposited in beds ready for use, and the *carclazite*, or true porcelain clay, of Cornwall and Devon obtained from the decomposed granitic rocks (known in Cornwall as “growan”) by the various processes briefly described in a former chapter; having also given what little information is as yet available respecting the kaolins of China and Japan, and referred to the uncertainty still existing as to their being, as has been so generally assumed, really identical with the china clay of Cornwall and other European localities, I am anxious, to give some account of the china clays of Ireland and the rocks from which they are or may be obtained.

So far as the writer knows there are no indications of deposits of china clay being probably ever found in Scotland, although Bristow mentions its being found on the S.W. side of Fetlar,¹ one of the Shetland Islands. The writer cannot say, however, whether it exists in any quantity there, but, if it does,

¹ *Glossary of Mineralogy*, by H. W. Bristow, F.G.S. London, 1861. Under “Kaolin Localities.”

its distance and the extremely exposed and storm-ridden coasts of the Shetlands, renders it improbable that Fetlar will ever be looked to as a source of supply of china clay for our English potteries. The late Dr. Thomson, of Glasgow, who was a most enthusiastic mineralogist as well as chemist, and who devoted nearly all his spare time for ten years to the study and chemical analysis of rocks and minerals, especially those of Scotland, does not mention, in his work on Mineralogy, etc.,¹ either Fetlar, or any other place in Scotland, as a locality for china clay, nor does he mention any locality there for felspar (although felstone is abundant in many localities) or petrosilex—rocks from which it might be derived; and no subsequent Scottish geologist or mineralogist, so far as the writer knows, has indicated the probability of china clay being obtained in quantity there, or any at all elsewhere in Scotland; or the existence there of *pegmatite* or *protogene*, or any other variety of granitic rock, such as those from which, by decomposition, the soft “growan” of Cornwall is derived.

This being so, should the question—as in the case of coal—ever be raised as to the probability of the exhaustion of the Cornish and Devonshire china clays, and as to where our porcelain manufacturers and potters can, in such an eventuality, look for the supply of that material, or a substitute for it, to keep their works going, the writer believes the reply must be—to that so long neglected but most important part of the United Kingdom, Ireland, which, if the sea that surrounds it be the “melancholy ocean,” as designated by a lately deceased statesman, it is at all events a narrow one, speedily and safely traversed at all times, and, when crossed, revealing a country of magnificent harbours and inexhaustible water-power, and, indeed, a real El Dorado of metallic and mineral wealth of

¹ *Outlines of Mineralogy, Geology, and Mineral Analysis*, by Thos. Thomson, M.D., Regius Professor of Chemistry in the University of Glasgow, 2 vols. London, 1836.

every sort, requiring only a modicum of common sense and submission to law on the part of its natives, and the thereupon speedy investment of capital, to develop its resources, and cause the "Emerald Isle" to smile with prosperity and wealth, by the development of mining and manufacturing industries, which might in time rival those of any other part of the kingdom at home or of the empire abroad; by which, along with the other remedial agencies now so effectually in operation, an end would speedily be put for ever to the agrarian violence that now disgraces it, and Irish hovels be changed into comfortable homesteads and their at present discontented inmates into prosperous and loyal subjects of His Majesty the King. May God thus, as well as in other ways, bless old Ireland!

The writer has mentioned several localities in Ireland where there are deposits of pipe clay similar and equal in quality to those of Bovey Tracey in Devonshire, and the various Dorsetshire beds, and from some of which large quantities have been imported to England for potting purposes. So far as the writer has been able to ascertain, however, the chief localities in Ireland where porcelain clay occurs are Belleek, near Lough Erne, in the County of Fermanagh, where, according to Kinaghan,¹ there is a range of an endogenous granitic vein rock of pink orthoclase felspar, which is extensively worked by the Belleek Pottery Company, of which the writer hopes to give a more detailed account in a future article; Kilraneagh, near Baltinglass, County Wicklow, where china clay of a fine quality has been obtained; a locality a little S.E. of Westport, County Mayo, where a decomposed dyke of petrosilex forms a dyke of china clay; and Tullow, County Carlow, but where the porcelain clay is partly impregnated with iron. There are also masses of decomposed granite in the Mourne Mountains, County Down, which yield china clay; but

¹ *Manual of the Geology of Ireland*, by G. H. Kinaghan, M.R.I.A., of H.M. Geological Survey. London, 1878.

of these localities, the available information, so far as regards their being future probable sources of supply of porcelain clay, is exceedingly scanty, and the writer is in hopes of having ere long an opportunity of personally ascertaining how far they are likely to be so.

Little attention has, however, been paid as yet, and but little information is available, as to the extent of porcelain clay deposits in Ireland, or of the rocks which by their decomposition furnish it, and the writer cannot, from personal knowledge, say anything very definite on this point, but he believes that large supplies of this, as well as of pipe and other pottery clays, can be obtained from various of its counties. Dr. Kane¹ mentions that in many of the granitic districts of Ireland the felspar is found decomposed, and that, by means of the same artificial processes employed in Cornwall, porcelain clay can be obtained from it. It is not, however, so much to these he looks for future supplies of material for porcelain manufacturers, but to what he believes will be found to be inexhaustible sources of such material, viz., the extensive ranges of petrosilex occurring in many parts of Ireland, and which, so far as he can determine from the very scanty means available as yet in England for determining the subject, is identical with the chief material used for the manufacture of hard porcelain, both in China and Japan, in the latter of which country, if not in both, no such material as that generally called kaolin, and assumed to be identical with our English china clay, or earclazite, is used in the manufacture of Japanese porcelain (as mentioned on pp. 100, 101), nor probably (according to the statement of Baron von Richtofen, quoted on p. 95) in that of Chinese porcelain either.

Petrosilex is a very hard siliceous variety of felspar (of which only one very small specimen from China is to be found in

¹ *Industrial Resources of Ireland*, by Robert Kane, M.D., 2nd edition. Dublin, 1845.

the Jermyn Street Museum, as mentioned and described in a former chapter, by the use of which our porcelain manufacturers might probably produce a body rivalling in every respect that of the best Oriental manufacturers.

According to Kinaghan, dykes of petrosilex are specially numerous in Errisbeg, the country westward of Roundstone, County of Galway; while Warren recorded many of them in the area to the north of the Erriff valley, County of Mayo. They also occur in Wexford and neighbouring counties, in the vicinity of the granitic districts. There is, in fact, no doubt of the very extensive occurrence of this rock, and of the inexhaustible source it offers for the supply of this valuable material for porcelain manufacture.

CHAPTER XV

IRISH CLAYS—ANALYSIS—COMPARISON WITH JAPANESE CLAYS

IN now bringing these chapters on clays to a close, the writer regrets his inability to give further information regarding the materials existing in Ireland for the manufacture of porcelain, in which so very successful results have been achieved by the enterprise and taste of the Belleek Pottery Co., in County Fermanagh. The writer was indebted to Mr. Armstrong for information regarding the felspar and porcelain clay of that county.

Judging from the almost entire absence of Irish localities for it, in mineralogical works, the common orthoclase felspar, which has now to be brought all the way from Norway for our porcelain manufacturers, is of rare occurrence in Ireland. Bristow, for instance, gives only the single locality of Slieve Corra, Mourne Mountains, for it, and there apparently it occurs only in crystals, and not in the massive form; although the decomposed masses of granite in these mountains, which were referred to as yielding china clay, are doubtless derived from its felspathic constituent, and that may probably be orthoclase. As shown, however, in the last chapter, from Kinaghan, Ireland possesses numerous dykes of petrosilex, of identical composition to the one near Westport, County Mayo, mentioned by him as having by decomposition been changed into a dyke of china clay; and it has also numerous other varieties of felsites of similar composition.

The officers of the Geological Survey do not, as a rule, apparently consider it part of their duty to point out such

rocks in Ireland as might furnish materials for technical purposes, but Jukes, in his *Manual of Geology*,¹ quotes analyses of petrosilex by Durocher, the mean of which is as follows:—

Silica	75·40
Alumina ²	15·00
Potash	3·10
Soda	1·30
Lime	0·80
Magnesia	1·10
Oxides of iron and manganese	2·30
Loss	1·00
	100·00

Now this bears so remarkable a resemblance to the mineral which Dr. J. Hoffman, in his description of the porcelain quarries of Japan, describes as white and hard as rock, and which the Japanese, he says, break with hammers and pulverise in mills as an ingredient of their porcelain, that, for convenience of contrasting them, it may be as well to repeat here Malagetti's analysis of it, quoted by Janvier, and given in a former article, viz. :—

Silica	75·09
Alumina	20·00
Potash	3·05
Lime	0·06
	98·20

The writer will not presume to say whether this mineral is the kaolin or the petuntze of the Chinese and Japanese porcelain manufacturers, but it is undoubtedly one of the two; and

¹ *The Student's Manual of Geology*, by J. Beete Jukes, M.A., F.R.S., Local Director of the Geological Survey of Ireland. Edinburgh: A. & C. Black, 1862.

² Another analyses gives 18·00, which makes the resemblance to the Japanese mineral still closer.

whichever of the two it is, it is not got, like our china clay, from a decomposed rock, but is reduced from a hard siliceous rock to a fine powder, for an ingredient of porcelain, by the processes just referred to, and which, as previously mentioned, are also the processes by which the hard mineral "Yeon-ko" is prepared by the Chinese for their porcelain bodies.

In closing these chapters on porcelain clays, I beg leave to state my belief that the enterprising porcelain manufacturers of England would do well to direct their attention to the petrosilex and other highly siliceous felsites of Ireland, for the purpose of still further rivalling, if not excelling, the best porcelain bodies of the Japanese, who are at present unrivalled in the higher productions of their art.

These chapters being limited to clays as potting materials, the writer considers it unnecessary to describe the various uses to which pottery clays, and especially china clays, are now so extensively used in numerous other manufactures and manufacturing processes, and there is the less need for his doing so, as this information is given in numerous cyclopædias. It is certainly a subject of very great and increasing interest, as the varied applications of these clays to technical purposes are constantly expanding, and likely to be indefinitely increased.

The opinion of the mineral and metallic wealth of Ireland, expressed by me on p. 112, may doubtless appear to some readers an exaggerated one; but while I purposely state my opinion strongly, in the hope of directing the attention of my readers to that part of the United Kingdom, I have not done so without good grounds. In a list, published in Dublin for H.M. Stationery Office in 1854, of localities in 29 counties of Ireland, in which mines and metalliferous indications and minerals had been discovered previous to that date (now thirty years ago), there are no fewer than 238 localities for lead—in numerous cases rich in silver; 209 for copper, one having native copper; 34 for zinc; 37 for clay ironstone, and other

iron ores, including hematite ; 11 for silver and auriferous silver ores ; 5 in which gold (formerly very abundant in Ireland) is found, and 2 of auriferous gossans ; 7 for antimony ; 3 for tin ; 1 for bismuth ; 1 for arsenic ; 2 for cobalt ; 11 for manganese ; 8 for sulphate of barytes ; 5 for mundies, and 30 for sulphur ores—a list which could now be greatly extended, apart altogether from its deposits of rock salt, gypsum, soapstone, bog iron ores, now so extensively used for the purification of gas, and valuable limestones and marbles, slates, granite, and other building stones, and its extensive beds of pipe and china clays, fire clays, and coal. There is an abundance of corroborative testimony as to these, to be had by those who will take the trouble to inquire ; and there can be no doubt entertained, by those who do so thoroughly, that security for the investment of that capital, which is now almost becoming a drug in Lombard Street and the City, is all that is wanting to develop these abundant metalliferous mineral deposits of Ireland, and thereby revolutionise the condition of that country, by providing remunerative employment for thousands and tens of thousands of its at present half-starved and pauperised population.

CHINA STONE

CHAPTER XVI

COMPOSITION—OCCURRENCE --ANALYSES

CHINA stone, or, as it is sometimes called, Cornish stone, from its being obtained from Cornwall, and there only in the United Kingdom, is a granitic rock, chiefly composed of white or pale brown quartz and white felspar, with occasionally a little light yellowish or greenish *gilbertite* and also flakes of *lepidolite*, a white lithia mica -- neither of which, if only in very small quantities, injure the economic value of the stone; but when it contains any larger quantity of either, or of brown or black schorl, it is useless for potting purposes. It is essentially a quartzose felspathic rock—the quartz, however, being much in excess of the felspar, and the latter often in a more or less decomposed condition. The best qualities of the stone contain fluorine, which greatly increases its fusibility, and that of St. Stephen's, which contains a considerable proportion of it, is in consequence much preferred by potters. The felspar of the stone is chiefly *orthoclase* (potash felspar) with a little *albite* (soda felspar).

China stone varies much in hardness, and, while its constituent felspars are usually more or less decomposed by atmospheric and other agencies in the "stone" supplied to the potteries, its harder varieties are pretty durable, and, being easily wrought, they are much used locally for building purposes, especially in the St. Stephen's district, where it is

chiefly worked, and has long been largely employed for building purposes, not only for dwelling-houses, and farm-steadings, etc., but also for churches—the fine towers of St. Stephen's and Probus Churches may be cited as examples of its adaptability and durability for public buildings; and in the neighbouring districts it is largely used and known by the name of "St. Stephen's stone."

In Cornwall the china stone is produced by the partial decomposition of *pegmatite*, by atmospheric influences, and that of hydro-fluoric acid, which is never absent and is generally derived from *lepidolite* and other fluorine minerals. *Pegmatite* is a binary granite, composed chiefly of quartz and felspar with more or less fluorine—the felspar lying impacted in the quartz, as crystals or otherwise, as in a matrix, with more or less of the silvery white mica—and often passing into *graphic* granite. Some writers, however, describe the "stone" as being produced by the decomposition of *protogine* (Gr. *protos*, first, and *ginomai*, I am formed, and so named under the erroneous idea of its being the *first-formed* of all the granites), the French term for talcose granite, composed of quartz, felspar, and talc; but Collins says, in his monograph,¹ "All the old writers speak of talcose granite, or *protogine*, as being abundant in the decomposed granite districts of Cornwall and elsewhere. What there may be elsewhere, I am not able to say, but there is certainly nothing of the kind at present known in Cornwall"; and as from his intimate knowledge of that county, and his special study of its granitic rocks, he is a most reliable authority on the question, the latter opinion of the source of Cornish stone may be dismissed from consideration.

China stone is now generally considered to be identical with the Chinese *petuntze*. That name, however, is a singularly unfortunate one, its literal meaning being "little white brick"

¹ *The Hensbarrow Granite District*, by J. H. Collins, F.G.S. Lake & Lake, Truro, 1878,

(*pe*, white, *tun*, brick or block, and *tze*, little), and the other or infusible ingredient of their porcelain being also made up into similar white bricks.

This infusible ingredient, similar in character but of a different origin to our china clay, or kaolin, being obtained either from the natural decomposition, or by the complete artificial pulverisation by stamps, of a variety of *petrosilex*, a very hard, compact, siliceous felspar, called by the Chinese *caulin* (*kaoling*—Chinese for *high ridge*), from a high ridge where it was first discovered, and from which it was conveyed (till some centuries ago, when the rock there was exhausted) for the supply of the numerous potteries of King-te-chin in the form also of small bricks. These bricks may probably have some distinguishing mark or stamp impressed upon them, but whether so or not, the similarity of their appearance has doubtless something to do with the confusion caused by travellers or writers having repeatedly confounded the one with the other. The two terms, however, *kaolin*, for porcelain or china clay, and *petuntze* for china stone, have now definitely been adopted in the Ceramic nomenclature of Europe.

It may be as well to mention here, in passing, that a similar petro-siliceous rock occurs abundantly in Ireland, in the form of irruptive dykes, which are in some localities found decomposed by atmospheric agency, *in situ*, into the finest china clay. Even where they are not so decomposed, they could furnish, by the use of stamps or grinding mills, an unlimited supply of the finest porcelain clay, and will doubtless do so when capital can safely be invested in that unfortunate country.

Janvier says that the "Chinese and Japanese porcelains are alike composed of a fusible and transparent, and an opaque and infusible, substance—the former, a quartzose feldspathic rock, calcined to deprive it of its water of crystallisation, and then

reduced to a fine powder, is the *petuntze*; the latter, the *kaolin*—

“Grind with strong arms, the pond’rous chert betwixt,
The soft *kaolin*, with *petuntze* mixed.”

As the composition of the latter rock, or china stone, varies considerably, it is advisable for the manufacturers of porcelain to ascertain, by an analysis of each lot, in what proportion the ingredients stand to each other. The Chinese use a flux with it, which they call “*oil*,” and which is a thin paste of lime and potash, the latter principally obtained from the burnt fronds of ferns.

Collins, in his monograph already quoted, gives the under noted analyses of china stone, Nos. 1 and 2 being the *mean* of two analyses of each sample, viz. :—

	No. 1.	No. 2.	No. 3.
Silica	73·39	69·50	71·66
Alumina	16·50	17·85	18·79
Potash, with a little soda . . .	7·66	7·98	6·60
Fluorine	0·74	0·71	0·14
Lime	0·50	2·66	1·70
Magnesia	0·31	0·12	0·35
Iron, only a trace	—	—	—
Water and loss	1·25	1·30	0·91
	100·35	100·12	100·15

Collins, who, in his monograph, proposed the name of *carclazite* as a specific name for the china clay of Cornwall, says therein, “Such an important rock as china stone ought also to have a specific name,” and proposed that of *petuntzite*,—and it is certainly desirable that both these names should be brought into use for general, or at least scientific, purposes. Owing to its large proportion of silica and potash with other alkaline ingredients, china stone is invaluable as a fluxing

material, and is generally used in the potteries in the manufacture both of earthenware and porcelain, being mixed, in varying proportions, after being reduced by grinding in water to a fine slip, with those of the clays and flint, which constitute the various bodies of these manufactures.

CHAPTER XVII

CHINA STONE—DISCOVERY AND USES

SOME obscurity still exists as to the relations between china stone (*petuntzite*) and the china clay granite (*carclazite*), although it is asserted by some writers, and indeed is generally assumed, that they are both products of one species of granite rock, differing only in the stage of decomposition in which they are found. *Petuntzite* being that granite so little affected by atmospheric and other agencies of decomposition as to remain hard, compact, and durable, in which state—as mentioned in the previous part of the last chapter—it is largely employed as a building stone; and even where occurring so much decomposed as to be easily broken down, when being quarried for export to the potteries, still retaining more or less of the alkaline ingredients of its constituent felspars, to which it owes its special value for employment in the manufacture of earthenware and porcelain. Then, when these felspars are thoroughly decomposed, the rains wash out the greater portion of their soluble alkalies, which are carried off to enrich the soil of the underlying valleys, leaving *in situ* the more or less pure silicate of alumina, which constitutes the china clay of Cornwall. This, whether occurring as a deposit *in situ*, or washed down and re-deposited in lower hollows of the granite range, is mixed with more or less of the quartz, mica, schorl, etc. (originally contained in the undecomposed granite), from which it is subsequently freed by artificial water action in its preparation for potting, and the

various other manufacturing processes for which it is now so largely employed.

While, however, as above mentioned, it is generally assumed that both the china stone and clay are the products of the same species of granite, there are some phenomena connected with the occurrence of the former in various places, such as St. Stephen's, St. Dennis, St. Austell, and others in the Hensbarrow granite district of Cornwall, which seem to indicate some specific difference between them. In the above district the china stone occurs in irregular patches, bands, and dykes in the granite, and, unlike the *carclazite*, or china clay rock, it does not appear to be necessarily connected with veins of schorl and other materials which are more or less largely characteristic of the latter; and as regards decomposition, it appears to occupy an intermediate position between it, on the one hand, and the hard, unaltered granite on the other. While *carclazite* also occasionally passes into *petuntzite* in depth, and more frequently in horizontal extension—and Collins states his belief that the latter is never found unconnected with the former—yet there are instances where, as for example at Little Treviscoe, in the parish of St. Stephen's, the china stone is found *above* an underlying mass of *carclazite*, and were there not some specific difference in the composition of their constituent felspars, it is difficult to understand how the latter could have been decomposed, while the former remained unaltered or undecomposed—both being subjected to the same decomposing agencies, and which naturally and generally decompose the overlying masses first. Again, sometimes crystalline masses are found enclosed in the china stone, having the appearance and composition of yellow mica, and yet the figures of these masses are those of a triclinic felspar, not found associated with the *carclazite*. Occasionally, too, crystals of undecomposed or partially decomposed felspars of different species occur in the "stone." Seen at a little distance,

there is little difference in the appearance of *petuntzite* and *carclazite*, and in Professor Sedgwick's description of the district where they chiefly occur,¹ it is evident that he misunderstood what he saw, and confounded the two; for, speaking of the decomposed granite, he says: "On a near examination it is found soft enough to be cut with a spade, and it is in that state packed up and exported to the potteries. In other pits on the same moor the rock is broken down by mechanical force, and a running stream of water is made to pass through the fragments, the beautiful white china clay resulting from this process." Collins, in his monograph already quoted, says that Dr. Fitton, who visited Cornwall in 1814, observed the facts somewhat more accurately than Professor Sedgwick, for he observed that most china clay works there had a stone quarry, and the "stone" is often so hard as to require wedging or blasting in quarrying it, the hardest being generally preferred as easiest for conveyance.² If it is taken a fathom or so from the surface, where it is quite solid, it is stained with an abundance of greenish spots—probably of fluor spar—a peculiarity which was noted in the Chinese *petuntze* by the Jesuit Father d'Entrecolles, who, when writing on Chinese potting materials in 1712, stated that such stones as had most of these greenish spots were the most proper for the preparation of the glaze; and Mr. Worth, in a paper on "William Cookworthy and the Plymouth China Factory,"³ says: "I believe this remark is just, as I know that such stones are the most easily vitriable, and that a vein of it in Tregonning Hill, in the parish of Germoe, is so much so, that it makes an excellent glaze without any addition of vitrescent ingredients."

The discovery of china stone in England, and its first employment for potting purposes there, is universally credited

¹ Vide *Cambridge Philosophical Transactions*, vol. i. pp. 404-5.

² Vide *Annals of Philosophy*, 1814, vol. iii. p. 181.

³ *Transactions of the Devonshire Association*, July 1876.

to Mr. William Cookworthy, a member of the Society of Friends.

He was born in Kingsbridge, in South Devon, on 12th April 1705, and established a pottery at Plymouth in 1733, in which he must at first have made only common earthenware, or otherwise have imported china clay from the Continent. He appears to have commenced a search for porcelain clay and china stone in England, in 1745, in consequence of his attention having been directed to these materials by an American, who submitted to him specimens of both which had been found in Virginia, and also of porcelain made from them. After a long personal search for similar materials, during which he rode over large tracts of Devonshire and Cornwall, his perseverance was rewarded by their discovery in the latter county. It has been said that Cookworthy first discovered *petuntzite* in the stones of the tower of St. Columb's Church, which was built of the "stone" from St. Stephen's, and that he identified it as similar to that shown to him by the American. His own account of it is, however, given in a letter of date 30th May 1745, quoted by Mr. Worth, in which he mentions having seen the specimens brought by an American from Virginia, and which he considered identical with the Chinese porcelain materials, specimens of which had been brought to Europe in 1712. He stated that "he first discovered the china stone in Tregonning Hill," and described it as "composed of small pellucid gravel (quartz) and a whitish material, which indeed is *caulin* (kaolin) petrified (evidently the partially-decomposed felspar), and as the *caulin* of Tregonning Hill hath abundance of mica in it, this stone hath it also." Then he goes on to describe the greenish spots in it, and its vitrescent qualities, as already mentioned above. He further mentions having chiefly employed the "stone" from Tregonning Hill in his factory, but that he had lately discovered that in the neighbourhood of St. Stephen's in Cornwall there were immense quantities of

both the *caulin* and the *petuntze*, which he believed might be more commodiously and advantageously wrought than those of Tregonning Hill, and by experiments he had made with them, he found "they produced a much whiter body, and do not shrink by far so much in baking, nor take stains so readily by the fire." "The parish of St. Dennis, too," he believed, "contained both these materials in plenty." "I know," he adds, "two quarries of the 'stone,' one just above St. Stephen's (Church Town), the other, called Caluggas, somewhat more than a mile from it, appears to have the finer 'stone.'"

In the specifications for a patent for the employment of the china stone and clay in the manufacture of porcelain, by Cookworthy, granted in 1755, and renewed in 1768, he claims the discovery of both in England, as his own, and calls the stone *growan* and *moor-stone*, and the clay *growan-clay*.

The china stone requires but little preparation for market. The overburden is removed, and the stone roughly quarried, and where the rock is traversed by numerous joints, which it generally is, this is easily effected and usually without blasting, which is, however, sometimes necessary. Very few of the pits or quarries are worked to any great depth, seldom more than 10 or 12 fathoms, as the upper stone is worked at much less cost than the underlying, and few of the pits have any facilities for deep drainage by adit levels. The joints of the "stone" are usually discoloured by green vegetable stains, brown ones, due to oxide of iron, or black ones, due to oxide of manganese. The stones are dressed by chipping with an axe, by which they are freed from most of these stains, and in the large potteries (or in the flint mills which supply it ground, in the liquid or dried state, to the smaller factories), it is finely ground in water to the consistency of cream, and mixed in due proportions with the flint and clay slips for the various bodies for which it is now so generally employed.

From the following analysis of *Tsuji-chu-chi*, a Japanese porcelain stone—

Silica	80·672
Alumina	16·174
Soda	1·799
Potash	·569
Magnesia	·102
Ferrous oxide	·684
Manganese	trace
	100·000

it will be noticed, by a comparison of it with the analyses of china stone, that while it has a larger percentage of silica, it is deficient in the alkalis, having 2·368 of soda and potash combined, whereas the average of these in the three analyses there given is 7·413. This is doubtless the reason why the Oriental porcelain manufacturers have to add a flux of lime and potash to their ground *petuntzite*, as mentioned in the former part of this chapter.

It may be mentioned that while only 10 per cent. or so of the china clay of Cornwall is exported for employment in potting, the whole of the china stone exported is solely for that purpose.

THE END

INDEX

- ABEL, Prof. F. A., 16.
 Albite, 53, 56, 120.
 Alumina, 1.
 Analysis of ball clay, 40.
 Analysis of black clay, 34.
 Analysis of black crucible clay, 21.
 Analysis of blue clay, 41.
 Analysis of brick clay, 12.
 Analysis of brown clay, 34.
 Analysis of carclazite, 81.
 Analysis of china clay, 58, 72, 73, 74, 75.
 Analysis of china stone, 123.
 Analysis of Cornish granite, 60.
 Analysis of Cornwall clay, 72.
 Analysis of fire clay, 17, 18.
 Analysis of glasshouse pot clay, 20.
 Analysis of granite, 52.
 Analysis of Japanese porcelain, 96.
 Analysis of Japanese porcelain stone, 130.
 Analysis of kaolin, 101, 102, 103.
 Analysis of marl, 20.
 Analysis of orthoclase, 52.
 Analysis of petuntze, 96.
 Analysis of pipe clay, 25.
 Analysis of Poole clay, 35, 40.
 Analysis of porcelain clays, 109.
 Analysis of porcelain spar, 71.
 Analysis of Teignmouth clay, 40.
 Analysis of Welsh roofing slate, 7.
 Analysis of white pipe clay, 32.
 Analysis of yellow pipe clay, 33.
 Anorthite, 56.
 Ansted, 9, 41, 53, 58.
 Argile plastique, 22.
 BALL clay, 24, 40.
 Ballast, 12.
 Berlin Royal Factory, 46.
 Black clay, 24, 33.
 Black crucible clay, 21.
 Blue clay, 34, 40.
 Böase, Dr., 62, 63, 64.
 Böttcher, 44.
 Boulder clay, 8.
 Bovey Tracey beds, 28.
 Brick clays, 7, 8.
 Brick-earths, 8.
 Brogniart, 3.
 Brown clay, 34.
 CAPLE, 79.
 Carclazite, 77, 125.
Catalogue of British Pottery and Porcelain, 17.
 China clay, 24.
 China clay, working of, 78, 79, 83.
 China stone, 120.
 Chinese porcelain, 44.
 Clarc lazine, 50.
 Clay, 1.
Clay and Plastic Strata of Great Britain, 3, 11, 27, 31.
 Clay, drying of, 83.
 Clay slate, 5.
 Collins' Hensbarrow Granite District, 51, 55, 60, 76, 77, 127.
 Cookworthy, William, 48, 128.
 Cornish clay, 50.
 Cracking clay, 24, 34.
 DE LA BECHE, 38, 43, 59.
 Donaldson, Professor, 11.
 Dorsetshire pipe clay, 25.
 "Dry," 83.
 Drying of clay, 83.
 EOCENE clay, 22.
 FEOULEANG annals, 87.
 Figuline, 22.

Fire clays, 7, 15.
 Fluorine, 55.
 Fuchs, Professor, 65, 66.

GEHLEN, Mr., 67, 68.
 Gilbertite, 120.
 Glasgow fire clay, 19.
 Glasshouse pot clay, 16.
 Growan, 51, 129.
 Growan-clay, 129.

HAWKINS, Mr. John, 61, 63, 64.

IRISH clays, 113.
 Iron oxide, 2.

JANVIER, 23.
 Japanese porcelain, 96, 104, 105.
 Japanese porcelain stone, 130.
 Johnson and Blake, 108.
 Jukes, 15.

KAOLIN, 24, 45, 48, 87, 98.
 Kaolin, formation of, 54.
 Kaolinite, 108.
 Kellberg, 46.

LABRADORITE, 56.
 Lepidolite, 55, 120, 121.
 Lignite, 25.
 "Linhay," 83.
 Loam, 5.
 Lower Bagshot beds, 28.
 Lower Tertiary beds, 24.

MANUFACTURE of Chinese por-
 celain, 87.
 Marl, 5, 18.
 Maw, George, F.G.S., 3, 11, 35, 36.
 Meissen porcelain, 44.
 Mica, 80.
 Mica clay, 80.
 Miller's *Philosophical Transactions*,
 28.
 Miocene beds, 24.
 Moor-stone, 129.

NUNGARROW porcelain, 19.

OIL of lime, 99, 123.
 Oligoclase, 56.
 Orthoclase, 52, 56, 116, 120.
 "Overburden," 79.

PEGMATITE, 59, 121.
 Petrosilex, 99, 100, 115, 122.
 Petuntze, 89, 91, 96, 98.
 Petuntzite, 123, 125.
 Pipe clay, 24, 32.
 Poole clays, 27, 39, 40.
 Porcelain clay, 50.
 Porcelain spar, 71.
 Pottery clay, 22, 42.
 Protogene, 59, 121.

REAUMUR'S experiments with
 kaolin and petuntze, 93.
 Rudley's *Catalogue of Specimens*,
 37, 41.

ST. YRIEIX kaolin, 47.
 Saxon porcelain, 44.
 Schnorr's white earth, 45.
 Seat-earth, 16.
 Seggars, 19.
 Sèvres Manufactory, 46.
 Shale, 5.
 Shell, 79.
 Shorl, 59.
 Silica, 1.
 Staffordshire ware, 39.
 Steinmark, 109.
 Stourbridge clay, 16.

TALC, 64.
 Teignmouth clays, 38, 39, 40.
 Tomlinson, 3.
 Tourmaline, 60.

UNDER-CLAY, 16.

WATSON'S *Chemical Essays*, 30.
 Weed, 79.
 Welsh roofing slate, analysis of, 7.
 White soda felspar, 53.
 Woodward's *Geology of England*,
 28.

Catalogue

OF

Special Technical Books

FOR

MANUFACTURERS, TECHNICAL STUDENTS AND
WORKERS, SCHOOLS, COLLEGES, ETC.
BY EXPERT WRITERS

INDEX TO SUBJECTS.

PAGE		PAGE		PAGE	
Agricultural Chemistry	10	Dye-stuffs	23	Paper-pulp Dyeing	17
Air, Industrial Use of	12	Enamelling Metal	18	Petroleum	6
Alum and its Sulphates	9	Enamels	18	Pigments, Chemistry of	2
Ammonia	9	Engraving	31	Plumbers' Work	27
Aniline Colours	3	Essential Oils	7	Porcelain Painting	17
Animal Fats	6	Evaporating Apparatus	26	Pottery Clays	16
Anti-corrosive Paints	4	External Plumbing	27	Pottery Manufacture	14
Architecture, Terms in	30	Fats	5, 6	Power-loom Weaving	19
Architectural Pottery	15	Faults in Woollen Goods	21	Preserved Foods	30
Artificial Perfumes	7	Gas Firing	26	Printers' Ready Reckoner	31
Balsams	10	Glass-making Recipes	16	Printing Inks	3
Bibliography	32	Glass Painting	17	Recipes for Oilmen, etc.	3
Bleaching	23	Glue Making and Testing	8	Resins	10
Bone Products	8	Greases	5	Risks of Occupations	11
Bookbinding	31	Hat Manufacturing	20	Rivetting China, etc.	16
Brick-making	15, 16	History of Staffs Potteries	16	Sanitary Plumbing	27
Burnishing Brass	28	Hops	28	Scheele's Essays	9
Carpet Yarn Printing	21	Hot-water Supply	28	Sealing Waxes	11
Ceramic Books	14, 15	How to make a Woollen Mill		Silk Dyeing	22
Charcoal	8	Pay	21	Silk Throwing	18
Chemical Essays	9	India-rubber	13	Smoke Prevention	26
Chemistry of Pottery	16	Industrial Alcohol	10	Soaps	7
Chemistry of Dye-stuffs	23	Inks	3, 11	Spinning	21
Clay Analysis	16	Iron-corrosion	4	Staining Marble, and Bone	31
Coal-dust Firing	26	Iron, Science of	26	Steam Drying	12
Colour Matching	22	Japanning	28	Sugar Refining	32
Colliery Recovery Work	25	Lace-Making	20	Steel Hardening	26
Colour-mixing for Dyers	22	Lacquering	28	Sweetmeats	30
Colour Theory	22	Lake Pigments	2	Terra-cotta	15
Combing Machines	24	Lead and its Compounds	11	Testing Paint Materials	4
Compounding Oils	6	Leather Industry	13	Testing Yarns	20
Condensing Apparatus	26	Leather-working Materials	14	Textile Fabrics	20
Cosmetics	8	Lithography	31	Textile Materials	19, 20
Cotton Dyeing	23	Lubricants	5, 6	Timber	29
Cotton Spinning	24	Manures	8, 10	Varnishes	5
Damask Weaving	20	Mineral Pigments	3	Vegetable Fats	7
Dampness in Buildings	30	Mine Ventilation	25	Waste Utilisation	10
Decorators' Books	28	Mine Haulage	25	Water, Industrial Use	12
Decorative Textiles	20	Oil and Colour Recipes	3	Waterproofing Fabrics	21
Dental Metallurgy	25	Oil Boiling	5	Weaving Calculations	21
Dictionary of Paint Materials	2	Oil Merchants' Manual	7	Wood Waste Utilisation	29
Drying Oils	5	Oils	5	Wood Dyeing	31
Drying with Air	12	Ozone, Industrial Use of	12	Wool Dyeing	22, 23
Dyeing Marble	31	Paint Manufacture	2	Writing Inks	11
Dyeing Woollen Fabrics	23	Paint Materials	3	X-Ray Work	13
Dyers' Materials	22	Paint-material Testing	4	Yarn Testing	20

PUBLISHED BY

SCOTT, GREENWOOD & SON,
8 BROADWAY, LUDGATE HILL,
LONDON, E.C.

Telegraphic Address, "Printeries, London".

Paints, Colours and Printing Inks.

THE CHEMISTRY OF PIGMENTS. By ERNEST J. PARRY, B.Sc. (Lond.), F.I.C., F.C.S., and J. H. COSTE, F.I.C., F.C.S. Demy 8vo. Five Illustrations. 285 pp. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. 3d. abroad.)

Contents.

Introductory. Light—White Light—The Spectrum—The Invisible Spectrum—Normal Spectrum—Simple Nature of Pure Spectral Colour—The Recomposition of White Light—Primary and Complementary Colours—Coloured Bodies—Absorption Spectra—**The Application of Pigments.** Uses of Pigments: Artistic, Decorative, Protective—Methods of Application of Pigments: Pastels and Crayons, Water Colour, Tempera Painting, Fresco, Encaustic Painting, Oil-colour Painting, Ceramic Art, Enamel, Stained and Painted Glass, Mosaic—**Inorganic Pigments.** White Lead—Zinc White—Enamel White—Whitening—Red Lead—Litharge—Vermilion—Royal Scarlet—The Chromium Greens—Chromates of Lead, Zinc, Silver and Mercury—Brunswick Green—The Ochres—Indian Red—Venetian Red—Siennas and Umbers—Light Red—Cappagh Brown—Red Oxides—Mars Colours—Terre Verte—Prussian Brown—Cobalt Colours—Cæruleum—Smalt—Copper Pigments—Malachite—Bremen Green—Scheele's Green—Emerald Green—Verdigris—Brunswick Green—Non-arsenical Greens—Copper Blues—Ultramarine—Carbon Pigments—Ivory Black—Lamp Black—Bistre—Naples Yellow—Arsenic Sulphides: Orpiment, Realgar—Cadmium Yellow—Vandyck Brown—**Organic Pigments.** Prussian Blue—Natural Lakes—Cochineal—Carmine—Crimson—Lac Dye—Scarlet—Madder—Alizarin—Campeachy—Quercitron—Rhamnus—Brazil Wood—Alkanet—Santal Wood—Archil—Coal-tar Lakes—Red Lakes—Alizarin Compounds—Orange and Yellow Lakes—Green and Blue Lakes—Indigo—Dragon's Blood—Gamboe—Sepia—Indian Yellow, Puree—Bitumen, Asphaltum, Mummy—**Index.**

THE MANUFACTURE OF PAINT. A Practical Handbook for Paint Manufacturers, Merchants and Painters. By J. CRUICKSHANK SMITH, B.Sc. Demy 8vo. 200 pp. Sixty Illustrations and One Large Diagram. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Preparation of Raw Material—Storing of Raw Material—Testing and Valuation of Raw Material—Paint Plant and Machinery—The Grinding of White Lead—Grinding of White Zinc—Grinding of other White Pigments—Grinding of Oxide Paints—Grinding of Staining Colours—Grinding of Black Paints—Grinding of Chemical Colours—Yellows—Grinding of Chemical Colours—Blues—Grinding Greens—Grinding Reds—Grinding Lakes—Grinding Colours in Water—Grinding Colours in Turpentine—The Uses of Paint—Testing and Matching Paints—Economic Considerations—**Index.**

DICTIONARY OF CHEMICALS AND RAW PRODUCTS USED IN THE MANUFACTURE OF PAINTS, COLOURS, VARNISHES AND ALLIED PREPARATIONS. By GEORGE H. HURST, F.C.S. Demy 8vo. 380 pp. Price 7s. 6d. net. (Post free, 8s. home; 8s. 6d. abroad.)

THE MANUFACTURE OF LAKE PIGMENTS FROM ARTIFICIAL COLOURS. By FRANCIS H. JENNISON, F.I.C., F.C.S. Sixteen Coloured Plates, showing Specimens of Eighty-nine Colours, specially prepared from the Recipes given in the Book. 136 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

The Groups of the Artificial Colouring Matters—The Nature and Manipulation of Artificial Colours—Lake-forming Bodies for Acid Colours—Lake-forming Bodies' Basic Colours—Lake Bases—The Principles of Lake Formation—Red Lakes—Orange, Yellow, Green, Blue, Violet and Black Lakes—The Production of Insoluble Azo Colours in the Form of Pigments—The General Properties of Lakes Produced from Artificial Colours—Washing, Filtering and Finishing—Matching and Testing Lake Pigments—**Index**

PAINTS, COLOURS, ETC.—*continued.*

THE MANUFACTURE OF MINERAL AND LAKE

PIGMENTS. Containing Directions for the Manufacture of all Artificial, Artists and Painters' Colours, Enamel, Soot and Metallic Pigments. A Text-book for Manufacturers, Merchants, Artists and Painters. By Dr. JOSEF BERSCH. Translated by A. C. WRIGHT, M.A. (Oxon.), B.Sc. (Lond.). Forty-three Illustrations. 476 pp., demy 8vo. Price 12s. 6d. net. (Post free, 13s. home; 13s. 6d. abroad.)

Contents.

Introduction—Physico-chemical Behaviour of Pigments—Raw Materials Employed in the Manufacture of Pigments—Assistant Materials—Metallic Compounds—The Manufacture of Mineral Pigments—The Manufacture of White Lead—Enamel White—Washing Apparatus—Zinc White—Yellow Mineral Pigments—Chrome Yellow—Lead Oxide Pigments—Other Yellow Pigments—Mosaic Gold—Red Mineral Pigments—The Manufacture of Vermilion—Antimony Vermilion—Ferric Oxide Pigments—Other Red Mineral Pigments—Purple of Cassius—Blue Mineral Pigments—Ultramarine—Manufacture of Ultramarine—Blue Copper Pigments—Blue Cobalt Pigments—Smalts—Green Mineral Pigments—Emerald Green—Verdigris—Chromium Oxide—Other Green Chromium Pigments—Green Cobalt Pigments—Green Manganese Pigments—Compounded Green Pigments—Violet Mineral Pigments—Brown Mineral Pigments—Brown Decomposition Products—Black Pigments—Manufacture of Soot Pigments—Manufacture of Lamp Black—The Manufacture of Soot Black without Chambers—Indian Ink—Enamel Colours—Metallic Pigments—Bronze Pigments—Vegetable Bronze Pigments.

PIGMENTS OF ORGANIC ORIGIN—Lakes—Yellow Lakes—Red Lakes—Manufacture of Carmine—The Colouring Matter of Lac—Safflower or Carthamine Red—Madder and its Colouring Matters—Madder Lakes—Manjit (Indian Madder)—Lichen Colouring Matters—Red Wood Lakes—The Colouring Matters of Sandal Wood and Other Dye Woods—Blue Lakes—Indigo Carmine—The Colouring Matter of Log Wood—Green Lakes—Brown Organic Pigments—Sap Colours—Water Colours—Crayons—Confectionery Colours—The Preparation of Pigments for Painting—The Examination of Pigments—Examination of Lakes—The Testing of Dye-Woods—The Design of a Colour Works—Commercial Names of Pigments—Appendix: Conversion of Metric to English Weights and Measures—Centigrade and Fahrenheit Thermometer Scales—Index.

RECIPES FOR THE COLOUR, PAINT, VARNISH, OIL, SOAP AND DRY-SALTERY TRADES.

Compiled by AN ANALYTICAL CHEMIST. 350 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 8s. home; 8s. 3d. abroad.)

Contents.

Pigments or Colours for Paints, Lithographic and Letterpress Printing Inks, etc.—Mixed Paints and Preparations for Paint-making, Painting, Lime-washing, Paperhanging, etc.—Varnishes for Coach-builders, Cabinetmakers, Wood-workers, Metal-workers, Photographers, etc.—Soaps for Toilet, Cleansing, Polishing, etc.—Perfumes—Lubricating Greases, Oils, etc.—Cements, Pastes, Glues and Other Adhesive Preparations—Writing, Marking, Endorsing and Other Inks—Sealing-wax and Office Requisites—Preparations for the Laundry, Kitchen, Stable and General Household Uses—Disinfectant Preparations—Miscellaneous Preparations—Index.

OIL COLOURS AND PRINTERS' INKS.

By LOUIS EDGAR ANDÉS. Translated from the German. 215 pp. Crown 8vo. 56 Illustrations. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

Linseed Oil—Poppy Oil—Mechanical Purification of Linseed Oil—Chemical Purification of Linseed Oil—Bleaching Linseed Oil—Oxidizing Agents for Boiling Linseed Oil—Theory of Oil Boiling—Manufacture of Boiled Oil—Adulterations of Boiled Oil—Chinese Drying Oil and Other Specialities—Pigments for House and Artistic Painting and Inks—Pigment for Printers' Black Inks—Substitutes for Lampblack—Machinery for Colour Grinding and Rubbing—Machines for mixing Pigments with the Vehicle—Paint Mills—Manufacture of House Oil Paints—Ship Paints—Luminous Paint—Artists' Colours—Printers' Inks—VEHICLES—Printers' Inks—PIGMENTS and MANUFACTURE—Index.

(See also *Writing Inks*, p. 11.)

THREE HUNDRED SHADES FOR DECORATORS AND HOW TO MIX THEM.

(See page 28.)

PAINTS, COLOURS, ETC.—*continued.*

CASEIN. By ROBERT SCHERER. Translated from the German by CHAS. SALTER. Demy 8vo. Illustrated. 160 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Casein: its Origin, Preparation and Properties. Various Methods of Preparing Casein. Composition and Properties of Casein. Casein Paints.—"Marble-Lime" Colour for Outside Work—Casein Enamel Paint—Casein Façade Paint—Cold-Water Paint in Powder Form—Kistory's Recipe for Casein Paint and Varnish—Pure Casein Paints for Walls, etc.—Casein Paints for Woodwork and Iron—Casein-Silicate Paints—Milk Paints—Casein-Silicate Paint Recipes—Trojel's Boiled Oil Substitute—Calsomine Wash—Quick-Drying Casein Paint—Boiled Oil Substitute—Ring's Cold-Water Paint—Formolactin—Waterproof Paint for Playing Cards—Casein Colour Lake—Casein-Cement Paint. The Technics of Casein Painting. Casein Adhesives and Putties.—Casein Glue in Plates or Flakes—Jeromin's Casein Adhesive—Hall's Casein Glue—Waterproof Glue—Liquid Casein Glue—Casein and Borax Glue—Solid Casein Adhesive—Casein Solution—Glue Powder—Casein Puttie.—Washable Cement for Deal Boards—Wenk's Casein Cement—Casein and Lime Cement—"Pitch Barn" Casein Stopping—Casein Cement for Stone. The Preparation of Plastic Masses from Casein.—Imitation Ivory—Anti-Radiation and Anti-Corrosive Composition—Dickmann's Covering for Floors and Walls—Imitation Linoleum—Imitation Leather—Imitation Bone—Plastic Mass of Keratin and Casein—Insulating Mass—Plastic Casein Masses—Horny Casein Mass—Plastic Mass from Celluloid—Casein Cellulose Composition—Fireproof Cellulose Substitute—Nitrocellulose and Casein Composition—Franquet's Celluloid Substitute—Galalith. Uses of Casein in the Textile Industry, for Finishing Colour Printing, etc.—Caseogum—"Glutin"—Casein Dressing for Linen and Cotton Fabrics—Printing Colour with Metallic Lustre—Process for Softening, Sizing and Loading—Fixing Casein and Other Albuminoids on the Fibre—Fixing Insoluble Colouring Matters—Waterproofing and Softening Dressing—Casein for Mercerising Crêpe—Fixing Zinc White on Cotton with Formaldehyde—Casein-Magnesia—Casein Medium for Calico Printing—Loading Silk. Casein Foodstuffs.—Casein Food—Synthetic Milk—Milk Food—Emulsifiable Casein—Casein Phosphate for Baking—Making Bread, Low in Carbohydrates, from Flour and Curd—Preparing Soluble Casein Compounds with Citrates—Casein Food. Sundry Applications of Casein.—Uses of Casein in the Paper Industry—Metachromotype Paper—Sizing Paper with Casein—Waterproofing Paper—Casein Solution for Coating Paper—Horn's Clear Solution of Casein—Water- and Fire-proof Asbestos Paper and Board—Paper Flasks, etc., for Oils and Fats—Washable Drawing and Writing Paper—Paper Wrapping for Food, Clothing, etc.—Paint Remover—Casein Photographic Plates—Wood-Cement Roofing Pulp—Cask Glaze of Casein and Formaldehyde—Artists' Canvas—Solidifying Mineral Oils—Uses of Casein in Photography—Casein Ointment—Clarifying Glue with Casein—Casein in Soap-making—Casein-Albumose Soap—Casein in Sheets, Blocks, etc.—Waterproof Casein.

SIMPLE METHODS FOR TESTING PAINTERS' MATERIALS. By A. C. WRIGHT, M.A. (Oxon.), B.Sc. (Lond.). Crown 8vo. 160 pp. Price 5s. net. (Post free, 5s. 3d. home; 5s. 6d. abroad.)

Contents.

Necessity for Testing—Standards—Arrangement—The Apparatus—The Reagents—Practical Tests—Dry Colours—Stiff Paints—Liquid and Enamel Paints—Oil Varnishes—Spirit Varnishes—Driers—Putty—Linseed Oil—Turpentine—Water Stains—The Chemical Examination—Dry Colours and Paints—White Pigments and Paints—Yellow Pigments and Paints—Blue Pigments and Paints—Green Pigments and Paints—Red Pigments and Paints—Brown Pigments and Paints—Black Pigments and Paints—Oil Varnishes—Linseed Oil—Turpentine.

IRON - CORROSION, ANTI - FOULING AND ANTI-CORROSIVE PAINTS. Translated from the German of LOUIS EDGAR ANDÉS. Sixty two Illustrations. 275 pp. Demy 8vo. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. 3d. abroad.)

Contents.

Iron-rust and its Formation—Protection from Rusting by Paint—Grounding the Iron with Linseed Oil, etc.—Testing Paints—Use of Tar for Painting on Iron—Anti-corrosive Paints—Linseed Varnish—Chinese Wood Oil—Lead Pigments—Iron Pigments—Artificial Iron Oxides—Carbon—Preparation of Anti-corrosive Paints—Results of Examination of Several Anti-corrosive Paints—Paints for Ship's Bottoms—Anti-fouling Compositions—Various Anti-corrosive and Ship's Paints—Official Standard Specifications for Ironwork Paints—Index.

THE TESTING AND VALUATION OF RAW MATERIALS USED IN PAINT AND COLOUR MANUFACTURE. By M. W. JONES, F.C.S. A Book for the Laboratories of Colour Works. 88 pp. Crown 8vo. Price 5s. net. (Post free, 5s. 3d. home and abroad.)

Contents.

Aluminium Compounds—China Clay—Iron Compounds—Potassium Compounds—Sodium Compounds—Ammonium Hydrate—Acids—Chromium Compounds—Tin Compounds—Copper Compounds—Lead Compounds—Zinc Compounds—Manganese Compounds—Arsenic Compounds—Antimony Compounds—Calcium Compounds—Barium Compounds—Cadmium Compounds—Mercury Compounds—Ultramarine—Cobalt and Carbon Compounds—Oils—Index.

STUDENTS' HANDBOOK OF PAINTS, COLOURS, OILS AND VARNISHES. By JOHN FURNELL. Crown 8vo. 12 Illustrations. 96 pp. Price 2s. 6d. net. (Post free, 2s. 9d. home and abroad.)

Contents.

Plant—Chromes—Blues—Greens—Earth Colours—Blacks—Reds—Lakes—Whites—Painters' Oils—Turpentine—Oil Varnishes—Spirit Varnishes—Liquid Paints—Enamel Paints.

Varnishes and Drying Oils.

OIL CRUSHING, REFINING AND BOILING, THE MANUFACTURE OF LINOLEUM, PRINTING AND LITHOGRAPHIC INKS, AND INDIA-RUBBER SUBSTITUTES. By JOHN GEDDES MCINTOSH. Being Volume I. of the Second, greatly enlarged, English Edition, in three Volumes, of "The Manufacture of Varnishes and Kindred Industries," based on and including the work of Ach. Livache. Demy 8vo. 150 pp. 29 Illustrations. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Oil Crushing and Refining; Oil Boiling—Theoretical and Practical; Linoleum Manufacture; Printing Ink Manufacture; Rubber Substitutes; The Manufacture of Driers; The Detection of Adulteration in Linseed and other Drying Oils by Chemical, Physical and Organoleptic Methods.

DRYING OILS, BOILED OIL AND SOLID AND LIQUID DRIERS. By L. E. ANDÉS. Expressly Written for this Series of Special Technical Books, and the Publishers hold the Copyright for English and Foreign Editions. Forty-two Illustrations. 342 pp. Demy 8vo. Price 12s. 6d. net. (Post free, 13s. home; 13s. 3d. abroad.)

Contents.

Properties of the Drying Oils; Cause of the Drying Property; Absorption of Oxygen; Behaviour towards Metallic Oxides, etc.—The Properties of and Methods for obtaining the Drying Oils—Production of the Drying Oils by Expression and Extraction; Refining and Bleaching; Oil Cakes and Meal; The Refining and Bleaching of the Drying Oils; The Bleaching of Linseed Oil—The Manufacture of Boiled Oil; The Preparation of Drying Oils for Use in the Grinding of Paints and Artists' Colours and in the Manufacture of Varnishes by Heating over a Fire or by Steam, by the Cold Process, by the Action of Air, and by Means of the Electric Current; The Driers used in Boiling Linseed Oil; The Manufacture of Boiled Oil and the Apparatus therefor; Livache's Process for Preparing a Good Drying Oil and its Practical Application—The Preparation of Varnishes for Letterpress, Lithographic and Copperplate Printing, for Oilcloth and Waterproof Fabrics; The Manufacture of Thickened Linseed Oil, Burnt Oil, Stand Oil by Fire Heat, Superheated Steam, and by a Current of Air—Behaviour of the Drying Oils and Boiled Oils towards Atmospheric Influences, Water, Acids and Alkalies—Boiled Oil Substitutes—The Manufacture of Solid and Liquid Driers from Linseed Oil and Rosin; Linolic Acid Compounds of the Driers—The Adulteration and Examination of the Drying Oils and Boiled Oil.

Oils, Fats, Greases, Petroleum.

LUBRICATING OILS, FATS AND GREASES: Their Origin, Preparation, Properties, Uses and Analyses. A Handbook for Oil Manufacturers, Refiners and Merchants, and the Oil and Fat Industry in General. By GEORGE H. HURST, F.C.S. Second Revised and Enlarged Edition. Sixty-five Illustrations. 317 pp. Demy 8vo. Price 10s. 6d. net. (Post free, 11s. home; 11s. 3d. abroad.)

Contents.

Introductory—Hydrocarbon Oils—Scotch Shale Oils—Petroleum—Vegetable and Animal Oils—Testing and Adulteration of Oils—Lubricating Greases—Lubrication—Appendices—Index.

TECHNOLOGY OF PETROLEUM: Oil Fields of the World—Their History, Geography and Geology—Annual Production and Development—Oil-well Drilling—Transport. By HENRY NEUBERGER and HENRY NOALHAT. Translated from the French by J. G. MCINTOSH. 550 pp. 153 Illustrations. 26 Plates. Super Royal 8vo. Price 21s. net. (Post free, 21s. 9d. home; 23s. 6d. abroad.)

Contents.

Study of the Petroliferous Strata.
Excavations—Hand Excavation or Hand Digging of Oil Wells.
Methods of Boring.
Accidents—Boring Accidents—Methods of preventing them—Methods of remedying them
 —Explosives and the use of the "Torpedo" Levigation—Storing and Transport of Petroleum
 —General Advice—Prospecting, Management and carrying on of Petroleum Boring Operations.
General Data—Customary Formulæ—Memento. Practical Part. General Data bearing on Petroleum—Glossary of Technical Terms used in the Petroleum Industry—Copious Index.

THE PRACTICAL COMPOUNDING OF OILS, TALLOW AND GREASE FOR LUBRICATION, ETC.

By AN EXPERT OIL REFINER. 100 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Introductory Remarks on the General Nomenclature of Oils, Tallow and Greases suitable for Lubrication—**Hydrocarbon Oils**—**Animal and Fish Oils**—**Compound Oils**—**Vegetable Oils**—**Lamp Oils**—**Engine Tallow**, **Solidified Oils** and **Petroleum Jelly**—**Machinery Greases**: Loco and Anti-friction—**Clarifying and Utilisation of Waste Fats, Oils, Tank Bottoms, Drainings of Barrels and Drums, Pickings Up, Dregs, etc.**—**The Fixing and Cleaning of Oil Tanks, etc.**—**Appendix and General Information.**

ANIMAL FATS AND OILS: Their Practical Production, Purification and Uses for a great Variety of Purposes. Their Properties, Falsification and Examination. Translated from the German of LOUIS EDGAR ANDÉS. Sixty-two Illustrations. 240 pp. Second Edition, Revised and Enlarged. Demy 8vo. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. 3d. abroad.)

Contents.

Introduction—Occurrence, Origin, Properties and Chemical Constitution of Animal Fats—**Preparation of Animal Fats and Oils**—**Machinery**—**Tallow-melting Plant**—**Extraction Plant**—**Presses**—**Filtering Apparatus**—**Butter**: Raw Material and Preparation, Properties, Adulterations, Beef Lard or Remelted Butter, Testing—**Candle-fish Oil**—**Mutton-Tallow**—**Hare Fat**—**Goose Fat**—**Neatsfoot Oil**—**Bone Fat**: Bone Boiling, Steaming Bones, Extraction, Refining—**Bone Oil**—**Artificial Butter**: Oleomargarine, Margarine Manufacture in France, Grasso's Process, "Kaiser's Butter," Jahr & Münzberg's Method, Filbert's Process, Winter's Method—**Human Fat**—**Horse Fat**—**Beef Marrow**—**Turtle Oil**—**Hog's Lard**: Raw Material—**Preparation, Properties, Adulterations, Examination**—**Lard Oil**—**Fish Oils**—**Liver Oils**—**Artificial Train Oil**—**Wool Fat**: Properties, Purified Wool Fat—**Spermaceti**: Examination of Fats and Oils in General.

THE MANUFACTURE OF LUBRICANTS, SHOE POLISHES AND LEATHER DRESSINGS.

By RICHARD BRUNNER. Translated from the Sixth German Edition by CHAS. SALTER. 10 Illustrations. Crown 8vo. 170 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

The Manufacture of Lubricants and Greases—Properties of the Bodies used as Lubricants—**Raw Materials for Lubricants**—**Solid Lubricants**—**Tallow Lubricants**—**Palm Oil Greases**—**Lead Soap Lubricants**—**True Soap Greases**—**Caoutchouc Lubricants**—**Other Solid Lubricants**—**Liquid Lubricants**—**Lubricating Oils in General**—**Rehning Oils for Lubricating Purposes**—**Cohesion Oils**—**Resin Oils**—**Lubricants of Fat and Resin Oil**—**Neatsfoot Oil**—**Bone Fat**—**Lubricants for Special Purposes**—**Mineral Lubricating Oils**—**Clockmakers' and Sewing Machine Oils**—**The Application of Lubricants to Machinery**—**Removing Thickened Grease and Oil**—**Cleaning Oil Rags and Cotton Waste**—**The Use of Lubricants**—**Shoe Polishes and Leather Softening Preparations**—**The Manufacture of Shoe Polishes and Preparations for Varnishing and Softening Leather**—**The Preparation of Bone Black**—**Blackening and Shoe Polishes**—**Leather Varnishes**—**Leather Softening Preparations**—**The Manufacture of Dégras.**

THE OIL MERCHANTS' MANUAL AND OIL TRADE READY RECKONER.

Compiled by FRANK F. SHERRIFF.
Second Edition Revised and Enlarged. Demy 8vo. 214 pp. 1904.
With Two Sheets of Tables. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. 3d. abroad.)

Contents.

Trade Terms and Customs—Tables to Ascertain Value of Oil sold per cwt. or ton—Specific Gravity Tables—Percentage Tare Tables—Petroleum Tables—Paraffine and Benzoline Calculations—Customary Drafts—Tables for Calculating Allowance for Dirt, Water, etc.—Capacity of Circular Tanks Tables, etc., etc.

VEGETABLE FATS AND OILS: Their Practical Preparation, Purification and Employment for Various Purposes, their Properties, Adulteration and Examination. Translated from the German of LOUIS EDGAR ANDÉS. Ninety-four Illustrations. 340 pp. Second Edition. Demy 8vo. Price 10s. 6d. net. (Post free, 11s. home; 11s. 6d. abroad.)

Contents.

General Properties—Estimation of the Amount of Oil in Seeds—The Preparation of Vegetable Fats and Oils—Apparatus for Grinding Oil Seeds and Fruits—Installation of Oil and Fat Works—Extraction Method of Obtaining Oils and Fats—Oil Extraction Installations—Press Moulds—Non-drying Vegetable Oils—Vegetable drying Oils—Solid Vegetable Fats—Fruits Yielding Oils and Fats—Wool-softening Oils—Soluble Oils—Treatment of the Oil after Leaving the Press—Improved Methods of Refining—Bleaching Fats and Oils—Practical Experiments on the Treatment of Oils with regard to Refining and Bleaching—Testing Oils and Fats.

Essential Oils and Perfumes.

THE CHEMISTRY OF ESSENTIAL OILS AND ARTIFICIAL PERFUMES.

By ERNEST J. PARRY, B.Sc. (Lond.), F.I.C., F.C.S. 411 pp. 20 Illustrations. Demy 8vo. Price 12s. 6d. net. (Post free, 13s. home; 13s. 6d. abroad.)

Contents.

The General Properties of Essential Oils—Compounds occurring in Essential Oils—The Preparation of Essential Oils—The Analysis of Essential Oils—Systematic Study of the Essential Oils—Terpeneless Oils—The Chemistry of Artificial Perfumes—Appendix: Table of Constants—Index.

Soaps.

SOAPS. A Practical Manual of the Manufacture of Domestic, Toilet and other Soaps. By GEORGE H. HURST, F.C.S. 390 pp. 66 Illustrations. Price 12s. 6d. net. (Post free, 13s. home; 13s. 6d. abroad.)

Contents.

Introductory—Soap-maker's Alkalies—Soap Fats and Oils—Perfumes—Water as a Soap Material—Soap Machinery—Technology of Soap-making—Glycerine in Soap Lyes—Laying out a Soap Factory—Soap Analysis—Appendices.

TEXTILE SOAPS AND OILS. Handbook on the Preparation, Properties and Analysis of the Soaps and Oils used in Textile Manufacturing, Dyeing and Printing. By GEORGE H. HURST, F.C.S. Crown 8vo. 195 pp. 1904. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

Methods of Making Soaps—Hard Soap—Soft Soap. Special Textile Soaps—Wool Soaps—Calico Printers' Soaps—Dyers' Soaps. Relation of Soap to Water for Industrial Purposes—Treating Waste Soap Liquors—Boiled Off Liquor—Calico Printers and Dyers' Soap Liquors—Soap Analysis—Fat in Soap.
ANIMAL AND VEGETABLE OILS AND FATS—Tallow—Lard—Bone Grease—Tallow Oil. Vegetable Soap, Oils and Fats—Palm Oil—Coco-nut Oil—Olive Oil—Cotton-seed Oil—Linseed Oil—Castor Oil—Corn Oil—Whale Oil or Train Oil—Repe Oil.

GLYCERINE.

TEXTILE OILS—Oleic Acid—Blended Wool Oils—Oils for Cotton Dyeing, Printing and Finishing—Turkey Red Oil—Alizarine Oil—Oleine—Oxy Turkey Red Oils—Soluble Oil—Analysis of Turkey Red Oil—Finisher's Soluble Oil—Finisher's Soap Softening—Testing and Adulteration of Oils—Index.

Cosmetical Preparations.

COSMETICS: MANUFACTURE, EMPLOYMENT AND TESTING OF ALL COSMETIC MATERIALS AND COSMETIC SPECIALITIES. Translated from the German of Dr. THEODOR KOLLER. Crown 8vo. 262 pp. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

Purposes and Uses of, and Ingredients used in the Preparation of Cosmetics—Preparation of Perfumes by Pressure, Distillation, Maceration, Absorption or Enflourage, and Extraction Methods—Chemical and Animal Products used in the Preparation of Cosmetics—Oils and Fats used in the Preparation of Cosmetics—General Cosmetic Preparations—Mouth Washes and Tooth Pastes—Hair Dyes, Hair Restorers and Depilatories—Cosmetic Adjuncts and Specialities—Colouring Cosmetic Preparations—Antiseptic Washes and Soaps—Toilet and Hygienic Soaps—Secret Preparations for Skin, Complexion, Teeth, Mouth, etc.—Testing and Examining the Materials Employed in the Manufacture of Cosmetics—Index.

Glue, Bone Products and Manures.

GLUE AND GLUE TESTING. By SAMUEL RIDEAL, D.Sc. (Lond.), F.I.C. Fourteen Engravings. 144 pp. Demy 8vo. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. abroad.)

Contents.

Constitution and Properties: Definitions and Sources, Gelatine, Chondrin and Allied Bodies, Physical and Chemical Properties, Classification, Grades and Commercial Varieties—**Raw Materials and Manufacture:** Glue Stock, Lining, Extraction, Washing and Clarifying, Filter Presses, Water Supply, Use of Alkalies, Action of Bacteria and of Antiseptics, Various Processes, Cleansing, Forming, Drying, Crushing, etc., Secondary Products—**Uses of Glue:** Selection and Preparation for Use, Carpentry, Veneering, Paper-Making, Book-binding, Printing Rollers, Hectographs, Match Manufacture, Sandpaper, etc., Substitutes for other Materials, Artificial Leather and Caoutchouc—**Gelatine:** General Characters, Liquid Gelatine, Photographic Uses, Size, Tanno-, Chrome and Formo-Gelatine, Artificial Silk, Cements, Pneumatic Tyres, Culinary, Meat Extracts, Isinglass, Medicinal and other Uses, Bacteriology—**Glue Testing:** Review of Processes, Chemical Examination, Adulteration, Physical Tests, Valuation of Raw Materials—**Commercial Aspects.**

BONE PRODUCTS AND MANURES: An Account of the most recent Improvements in the Manufacture of Fat, Glue, Animal Charcoal, Size, Gelatine and Manures. By THOMAS LAMBERT, Technical and Consulting Chemist. Illustrated by Twenty-one Plans and Diagrams. 162 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Chemical Composition of Bones—Arrangement of Factory—Properties of Glue—Glutin and Chondrin—Skin Glue—Liming of Skins—Washing—Boiling of Skins—Clarification of Glue Liquors—Glue-Boiling and Clarifying—House—Specification of a Glue—Size—Uses and Preparation and Composition of Size—Concentrated Size—Properties of Gelatine—Preparation of Skin Gelatine—Drying—Bone Gelatine—Selecting Bones—Crushing—Dissolving—Bleaching—Boiling—Properties of Glutin and Chondrin—Testing of Glues and Gelatines—The Uses of Glue, Gelatine and Size in Various Trades—Soluble and Liquid Glues—Steam and Waterproof Glues—**Manures**—Importation of Food Stuffs—Soils—Germination—Plant Life—**Natural Manures**—Water and Nitrogen in Farmyard Manure—Full Analysis of Farmyard Manure—Action on Crops—Water-Closet System—Sewage Manure—Green Manures—**Artificial Manures**—**Mineral Manures**—Nitrogenous Matters—Shoddy—Hoofs and Horns—Leather Waste—Dried Meat—Dried Blood—Superphosphates—Composition—Manufacture—Common Raw Bones—Degreased Bones—Crude Fat—Refined Fat—Degelatinised Bones—Animal Charcoal—Bone Superphosphates—Guanos—Dried Animal Products—Potash Compounds—Sulphate of Ammonia—Extraction *in Vacuo*—French and British Gelatines compared—Index.

Chemicals, Waste Products and Agricultural Chemistry.

REISSUE OF CHEMICAL ESSAYS OF C. W. SCHEELE. First Published in English in 1786. Translated from the Academy of Sciences at Stockholm, with Additions. 300 pp. Demy 8vo. Price 5s. net. (Post free, 5s. 6d. home ; 5s. 9d. abroad.)

Contents.

Memoir: C. W. Scheele and his work (written for this edition by J. G. McIntosh)—On Fluor Mineral and its Acid—On Fluor Mineral—Chemical Investigation of Fluor Acid, with a View to the Earth which it Yields, by Mr. Wiegler—Additional Information Concerning Fluor Minerals—On Manganese, Magnesium, or Magnesia Vitrariorum—On Arsenic and its Acid—Remarks upon Salts of Benzoin—On Silex, Clay and Alum—Analysis of the Calculus Vesical—Method of Preparing Mercurius Dulcis Via Humida—Cheaper and more Convenient Method of Preparing Pulvis Algarothi—Experiments upon Molybdæna—Experiments on Plumbago—Method of Preparing a New Green Colour—Of the Decomposition of Neutral Salts by Unslaked Lime and Iron—On the Quantity of Pure Air which is Daily Present in our Atmosphere—On Milk and its Acid—On the Acid of Saccharum Lactis—On the Constituent Parts of Lapis Ponderosus or Tungsten—Experiments and Observations on Ether—Index.

THE MANUFACTURE OF ALUM AND THE SULPHATES AND OTHER SALTS OF ALUMINA AND IRON. Their Uses and Applications as Mordants in Dyeing and Calico Printing, and their other Applications in the Arts, Manufactures, Sanitary Engineering, Agriculture and Horticulture. Translated from the French of LUCIEN GESCHWIND. 195 Illustrations. 400 pp. Royal 8vo. Price 12s. 6d. net. (Post free, 13s. home ; 13s. 6d abroad.)

Contents.

Theoretical Study of Aluminium, Iron, and Compounds of these Metals—Aluminium and its Compounds—Iron and Iron Compounds.

Manufacture of Aluminium Sulphates and Sulphates of Iron—Manufacture of Aluminium Sulphate and the Alums—Manufacture of Sulphates of Iron.

Uses of the Sulphates of Aluminium and Iron—Uses of Aluminium Sulphate and Alums—Application to Wool and Silk—Preparing and using Aluminium Acetates—Employment of Aluminium Sulphate in Carbonising Wool—The Manufacture of Lake Pigments—Manufacture of Prussian Blue—Hide and Leather Industry—Paper Making—Hardening Plaster—Lime Washes—Preparation of Non-inflammable Wood, etc.—Purification of Waste Waters—Uses and Applications of Ferrous Sulphate and Ferric Sulphates—Dyeing—Manufacture of Pigments—Writing Inks—Purification of Lighting Gas—Agriculture—Cotton Dyeing—Disinfectant—Purifying Waste Liquors—Manufacture of Nordhausen Sulphuric Acid—Fertilising.

Chemical Characteristics of Iron and Aluminium—Analysis of Various Aluminous or Ferruginous Products—Aluminium—Analysing Aluminium Products—Alunite—Alumina—Sodium Aluminate—Aluminium Sulphate—Iron—Analytical Characteristics of Iron Salts—Analysis of Pyritic Lignite—Ferrous and Ferric Sulphates—Rouil Mordant—Index.

AMMONIA AND ITS COMPOUNDS: Their Manufacture and Uses. By CAMILLE VINCENT, Professor at the Central School of Arts and Manufactures, Paris. Translated from the French by M. J. SALTER. Royal 8vo. 114 pp. Thirty-two Illustrations. Price 5s. net. (Post free, 5s. 4d. home ; 5s. 6d. abroad.)

Contents.

General Considerations: Various Sources of Ammoniacal Products; Human Urine as a Source of Ammonia—Extraction of Ammoniacal Products from Sewage—Extraction of Ammonia from Gas Liquor—Manufacture of Ammoniacal Compounds from Bones, Nitrogenous Waste, Beetroot Wash and Peat—Manufacture of Caustic Ammonia, and Ammonium Chloride, Phosphate and Carbonate—Recovery of Ammonia from the Ammonia-Soda Mother Liquors—Index.

INDUSTRIAL ALCOHOL. A Practical Manual on the Production and Use of Alcohol for Industrial Purposes and for Use as a Heating Agent, as an Illuminant and as a Source of Motive Power. By J. G. M'INTOSH, Lecturer on Manufacture and Applications of Industrial Alcohol at The Polytechnic, Regent Street, London. Demy 8vo. 1907. 250 pp. With 75 Illustrations and 25 Tables. Price 7s. 6d. net. (Post free, 7s. 9d. home ; 8s. abroad.)

Contents.

Alcohol and its Properties.—Ethylic Alcohol—Absolute Alcohol—Adulterations—Properties of Alcohol—Fractional Distillation—Destructive Distillation—Products of Combustion—Alcoholometry—Proof Spirit—Analysis of Alcohol—Table showing Correspondence between the Specific Gravity and Per Cents. of Alcohol over and under Proof—Other Alcohol Tables. **Continuous Aseptic and Antiseptic Fermentation and Sterilisation in Industrial Alcohol Manufacture.** The Manufacture of Industrial Alcohol from Beets.—Beet Slicing Machines—Extraction of Beet Juice by Maceration, by Diffusion—Fermentation in Beet Distilleries—Plans of Modern Beet Distillery. **The Manufacture of Industrial Alcohol from Grain.**—Plan of Modern Grain Distillery. **The Manufacture of Industrial Alcohol from Potatoes.** The Manufacture of Industrial Alcohol from Surplus Stocks of Wine, Spoilt Wine, Wine Mares, and from Fruit in General. The Manufacture of Alcohol from the Sugar Cane and Sugar Cane Molasses—Plans. **Plant, etc., for the Distillation and Rectification of Industrial Alcohol.**—The Caffey and other "Patent" Stills—Intermittent versus Continuous Rectification—Continuous Distillation—Rectification of Spent Wash. **The Manufacture and Uses of Various Alcohol Derivatives,** Ether, Haloid Ethers, Compound Ethers, Chloroform—Methyl and Amyl Alcohols and their Ethereal Salts, Acetone—Barbet's Ether, Methyl Alcohol and Acetone Rectifying Stills. **The Uses of Alcohol in Manufactures, etc.**—List of Industries in which Alcohol is used, with Key to Function of Alcohol in each Industry. **The Uses of Alcohol for Lighting, Heating, and Motive Power.**

ANALYSIS OF RESINS AND BALSAMS. Translated from the German of Dr. KARL DIETERICH. Demy 8vo. 340 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home ; 8s. 3d. abroad.)

MANUAL OF AGRICULTURAL CHEMISTRY. By HERBERT INGLE, F.I.C., Lecturer on Agricultural Chemistry, the Yorkshire College ; Lecturer in the Victoria University. 388 pp. 11 Illustrations. Demy 8vo. Price 7s. 6d. net. (Post free, 8s. home ; 8s. 6d. abroad.)

Contents.

Introduction—The Atmosphere—The Soil—The Reactions occurring in Soils—The Analysis of Soils—Manures, Natural—Manures (continued)—The Analysis of Manures—The Constituents of Plants—The Plant—Crops—The Animal—Foods and Feeding—Milk and Milk Products—The Analysis of Milk and Milk Products—Miscellaneous Products used in Agriculture—Appendix—Index.

THE UTILISATION OF WASTE PRODUCTS. A Treatise on the Rational Utilisation, Recovery and Treatment of Waste Products of all kinds. By Dr. THEODOR KOLLER. Translated from the Second Revised German Edition. Twenty-two Illustrations. Demy 8vo. 280 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home ; 8s. 3d. abroad.)

Contents.

The Waste of Towns—**Ammonia and Sal-Ammoniac**—Rational Processes for Obtaining these Substances by Treating Residues and Waste—Residues in the Manufacture of Aniline Dyes—Amber Waste—Brewers' Waste—Blood and Slaughter-House Refuse—Manufactured Fuels—Waste Paper and Bookbinders' Waste—Iron Slags—Excrement—Colouring Matters from Waste—Dyers' Waste Waters—Fat from Waste—Fish Waste—Calamine Sludge—Tannery Waste—Gold and Silver Waste—India-rubber and Caoutchouc Waste—Residues in the Manufacture of Rosin Oil—Wood Waste—Horn Waste—Infusorial Earth—Iridium from Goldsmiths' Sweepings—Jute Waste—Cork Waste—Leather Waste—Glue Makers' Waste—Illuminating Gas from Waste and the By-Products of the Manufacture of Coal Gas—Meerschum—Molasses—Metal Waste—By-Products in the Manufacture of Mineral Waters—Fruit—The By-Products of Paper and Paper Pulp Works—By-Products in the Treatment of Coal Tar Oils—Fur Waste—The Waste Matter in the Manufacture of Parchment Paper—Mother of Pearl Waste—Petroleum Residues—Platinum Residues—Broken Porcelain, Earthenware and Glass—Salt Waste—Slate Waste—Sulphur—Burnt Pyrites—Silk Waste—Soap Makers' Waste—Alkali Waste and the Recovery of Soda—Waste Produced in Grinding Mirrors—Waste Products in the Manufacture of Starch—Stearic Acid—Vegetable Ivory Waste—Turf—Waste Waters of Cloth Factories—Wine Residues—Tinplate Waste—Wool Waste—Wool Sweat—The Waste Liquids from Sugar Works—Index.

Writing Inks and Sealing Waxes.

INK MANUFACTURE : Including Writing, Copying, Lithographic, Marking, Stamping, and Laundry Inks. By SIGMUND LEHNER. Three Illustrations. Crown 8vo. 162 pp. Translated from the German of the Fifth Edition. Price 5s. net. (Post free, 5s. 3d. home; 5s. 6d. abroad.)

Contents.

Varieties of Ink—Writing Inks—Raw Materials of Tannin Inks—The Chemical Constitution of the Tannin Inks—Recipes for Tannin Inks—Logwood Tannin Inks—Ferric Inks—Alizarine Inks—Extract Inks—Logwood Inks—Copying Inks—Hektographs—Hektograph Inks—Safety Inks—Ink Extracts and Powders—Preserving Inks—Changes in Ink and the Restoration of Faded Writing—Coloured Inks—Red Inks—Blue Inks—Violet Inks—Yellow Inks—Green Inks—Metallic Inks—Indian Ink—Lithographic Inks and Pencils—Ink Pencils—Marking Inks—Ink Specialities—Sympathetic Inks—Stamping Inks—Laundry or Washing Blue—Index

SEALING-WAXES, WAFERS AND OTHER ADHESIVES FOR THE HOUSEHOLD, OFFICE, WORKSHOP AND FACTORY. By H. C. STANDAGE. Crown 8vo. 96 pp. Price 5s. net. (Post free, 5s. 3d. home; 5s. 6d. abroad.)

Contents.

Materials Used for Making Sealing-Waxes—The Manufacture of Sealing-Waxes—Wafers—Notes on the Nature of the Materials Used in Making Adhesive Compounds—Cements for Use in the Household—Office Gums, Pastes and Mucilages—Adhesive Compounds for Factory and Workshop Use.

Lead Ores and Compounds.

LEAD AND ITS COMPOUNDS. By THOS. LAMBERT, Technical and Consulting Chemist. Demy 8vo. 226 pp. Forty Illustrations. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. 3d. abroad.)

Contents.

History—Ores of Lead—Geographical Distribution of the Lead Industry—Chemical and Physical Properties of Lead—Alloys of Lead—Compounds of Lead—Dressing of Lead Ores—Smelting of Lead Ores—Smelting in the Scotch or American Ore-hearth—Smelting in the Shaft or Blast Furnace—Condensation of Lead Fume—Desilverisation, or the Separation of Silver from Argentiferous Lead—Cupellation—The Manufacture of Lead Pipes and Sheets—Protoxide of Lead—Litharge and Massicot—Red Lead or Minium—Lead Poisoning—Lead Substitutes—Zinc and its Compounds—Pumice Stone—Drying Oils and Siccatives—Oil of Turpentine Resin—Classification of Mineral Pigments—Analysis of Raw and Finished Products—Tables—Index.

NOTES ON LEAD ORES : Their Distribution and Properties. By JAS. FAIRIE, F.G.S. Crown 8vo. 64 pages. Price 2s. 6d. net. (Post free, 2s. 9d. home; 3s. abroad.)

Industrial Hygiene.

THE RISKS AND DANGERS TO HEALTH OF VARIOUS OCCUPATIONS AND THEIR PREVENTION.

By LEONARD A. PARRY, M.D., B.Sc. (Lond.). 196 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Occupations which are Accompanied by the Generation and Scattering of Abnormal Quantities of Dust—Trades in which there is Danger of Metallic Poisoning—Certain Chemical Trades—Some Miscellaneous Occupations—Trades in which Various Poisonous Vapours are Inhaled—General Hygienic Considerations—Index.

Industrial Uses of Air, Steam and Water.

DRYING BY MEANS OF AIR AND STEAM. Explanations, Formulæ, and Tables for Use in Practice. Translated from the German of E. HAUSBRAND. Two folding Diagrams and Thirteen Tables. Crown 8vo. 72 pp. Price 5s. net. (Post free, 5s. 3d. home; 5s. 6d. abroad.)

Contents.

British and Metric Systems Compared—Centigrade and Fahr. Thermometers—Estimation of the Maximum Weight of Saturated Aqueous Vapour which can be contained in 1 kilo. of Air at Different Pressure and Temperatures—Calculation of the Necessary Weight and Volume of Air, and of the Least Expenditure of Heat, per Drying Apparatus with Heated Air, at the Atmospheric Pressure: *A*, With the Assumption that the Air is *Completely Saturated* with Vapour both before Entry and after Exit from the Apparatus—*B*, When the Atmospheric Air is *Completely Saturated before entry*, but at its *exit* is only $\frac{3}{4}$, $\frac{1}{2}$ or $\frac{1}{4}$ Saturated—*C*, When the Atmospheric Air is *not Saturated* with Moisture before Entering the Drying Apparatus—Drying Apparatus, in which, in the Drying Chamber, a Pressure is Artificially Created, Higher or Lower than that of the Atmosphere—Drying by Means of Superheated Steam, without Air—Heating Surface, Velocity of the Air Current, Dimensions of the Drying Room, Surface of the Drying Material, Losses of Heat—Index.

(See also "*Evaporating, Condensing and Cooling Apparatus*," p. 26.)

PURE AIR, OZONE AND WATER. A Practical Treatise of their Utilisation and Value in Oil, Grease, Soap, Paint, Glue and other Industries. By W. B. COWELL. Twelve Illustrations. Crown 8vo. 85 pp. Price 5s. net. (Post free, 5s. 3d. home; 5s. 6d. abroad.)

Contents.

Atmospheric Air; Lifting of Liquids; Suction Process; Preparing Blown Oils; Preparing Siccative Drying Oils—Compressed Air; Whitewash—Liquid Air; Retrocession—Purification of Water; Water Hardness—Fleshings and Bones—Ozonised Air in the Bleaching and Deodorising of Fats, Glues, etc.; Bleaching Textile Fibres—Appendix: Air and Gases; Pressure of Air at Various Temperatures; Fuel; Table of Combustibles; Saving of Fuel by Heating Feed Water; Table of Solubilities of Scale Making Minerals; British Thermal Units Tables; Volume of the Flow of Steam into the Atmosphere; Temperature of Steam—Index.

THE INDUSTRIAL USES OF WATER. COMPOSITION—EFFECTS—TROUBLES—REMEDIES—RESIDUARY WATERS—PURIFICATION—ANALYSIS.

By H. DE LA COUX. Royal 8vo. Translated from the French and Revised by ARTHUR MORRIS. 364 pp. 135 Illustrations. Price 10s. 6d. net. (Post free, 11s. home; 11s. 6d. abroad.)

Contents.

Chemical Action of Water in Nature and in Industrial Use—Composition of Waters—Solubility of Certain Salts in Water Considered from the Industrial Point of View—Effects on the Boiling of Water—Effects of Water in the Industries—Difficulties with Water—Feed Water for Boilers—Water in Dyeworks, Print Works, and Bleach Works—Water in the Textile Industries and in Conditioning—Water in Soap Works—Water in Laundries and Washhouses—Water in Tanning—Water in Preparing Tannin and Dyewood Extracts—Water in Papermaking—Water in Photography—Water in Sugar Refining—Water in Making Ices and Beverages—Water in Cider Making—Water in Brewing—Water in Distilling—Preliminary Treatment and Apparatus—Substances Used for Preliminary Chemical Purification—Commercial Specialities and their Employment—Precipitation of Matters in Suspension in Water—Apparatus for the Preliminary Chemical Purification of Water—Industrial Filters—Industrial Sterilisation of Water—Residuary Waters and their Purification—Soil Filtration—Purification by Chemical Processes—Analyses—Index.

(See *Books on Smoke Prevention, Engineering and Metallurgy*, p. 26, etc.)

X Rays.

PRACTICAL X RAY WORK. By FRANK T. ADDYMAN, B.Sc. (Lond.), F.I.C., Member of the Roentgen Society of London; Radiographer to St. George's Hospital; Demonstrator of Physics and Chemistry, and Teacher of Radiography in St. George's Hospital Medical School. Demy 8vo. Twelve Plates from Photographs of X Ray Work. Fifty-two Illustrations. 200 pp. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. 3d. abroad.)

Contents.

Historical—Work leading up to the Discovery of the X Rays—The Discovery—**Apparatus and its Management**—Electrical Terms—Sources of Electricity—Induction Coils—Electrostatic Machines—Tubes—Air Pumps—Tube Holders and Stereoscopic Apparatus—Fluorescent Screens—**Practical X Ray Work**—Installations—Radioscopy—Radiography—X Rays in Dentistry—X Rays in Chemistry—X Rays in War—Index.

List of Plates.

Frontispiece—Congenital Dislocation of Hip-Joint.—I., Needle in Finger.—II., Needle in Foot.—III., Revolver Bullet in Calf and Leg.—IV., A Method of Localisation.—V., Stellate Fracture of Patella showing shadow of "Strapping".—VI., Sarcoma.—VII., Six-weeks-old Injury to Elbow showing new Growth of Bone.—VIII., Old Fracture of Tibia and Fibula badly set.—IX., Heart Shadow.—X., Fractured Femur showing Grain of Splint.—XI., Barrell's Method of Localisation.

India-Rubber and Gutta Percha.

INDIA-RUBBER AND GUTTA PERCHA. Translated from the French of T. SEELIGMANN, G. LAMY TORVILHON and H. FALCONNET by JOHN GEDDES MCINTOSH. Royal 8vo.

[Out of print. Second Edition in preparation.]

Contents.

India-Rubber—Botanical Origin—Climatology—Soil—Rational Culture and Acclimation of the Different Species of India-Rubber Plants—Methods of Obtaining the Latex—Methods of Preparing Raw or Crude India-Rubber—Classification of the Commercial Species of Raw Rubber—Physical and Chemical Properties of the Latex and of India-Rubber—Mechanical Transformation of Natural Caoutchouc into Washed or Normal Caoutchouc (Purification) and Normal Rubber into Masticated Rubber—Softening, Cutting, Washing, Drying—Preliminary Observations—Vulcanisation of Normal Rubber—Chemical and Physical Properties of Vulcanised Rubber—General Considerations—Hardened Rubber or Ebonite—Considerations on Mineralisation and other Mixtures—Coloration and Dyeing—Analysis of Natural or Normal Rubber and Vulcanised Rubber—Rubber Substitutes—Imitation Rubber.

Gutta Percha—Botanical Origin—Climatology—Soil—Rational Culture—Methods of Collection—Classification of the Different Species of Commercial Gutta Percha—Physical and Chemical Properties—Mechanical Transformation—Methods of Analysing—Gutta Percha Substitutes—Index.

Leather Trades.

PRACTICAL TREATISE ON THE LEATHER INDUSTRY. By A. M. VILLON. Translated by FRANK T. ADDYMAN, B.Sc. (Lond.), F.I.C., F.C.S.; and Corrected by an Eminent Member of the Trade. 500 pp., royal 8vo. 123 Illustrations. Price 21s. net. (Post free, 21s. 6d. home; 22s. 6d. abroad.)

Contents.

Preface—Translator's Preface—List of Illustrations.

Part I., Materials used in Tanning—Skins: Skin and its Structure; Skins used in Tanning; Various Skins and their Uses—Tannin and Tanning Substances: Tannin; Barks (Oak); Barks other than Oak; Tanning Woods; Tannin-bearing Leaves; Excrecences; Tan-bearing Fruits; Tan-bearing Roots and Bulbs; Tanning Juices; Tanning Substances used in Various Countries; Tannin Extracts; Estimation of Tannin and Tannin Principles.

Part II., Tanning—The Installation of a Tannery: Tan Furnaces; Chimneys, Boilers, etc.; Steam Engines—Grinding and Trituration of Tanning Substances: Cutting up Bark; Grinding Bark; The Grinding of Tan Woods; Powdering Fruit, Galls and Grains; Notes on the Grinding of Bark—Manufacture of Sole Leather: Soaking; Sweating and Unhairing; Plumping and Colouring; Handling; Tanning; Tanning Elephants' Hides; Drying; Striking or Pinning—Manufacture of Dressing Leather: Soaking; Depilation; New Processes for the Depilation of Skins; Tanning; Cow Hides; Horse Hides; Goat Skins; Manu-

facture of Split Hides—On Various Methods of Tanning: Mechanical Methods; Physical Methods; Chemical Methods; Tanning with Extracts—Quantity and Quality; Quantity; Net Cost; Quality of Leather—Various Manipulations of Tanned Leather: Second Tanning; Grease Stains; Bleaching Leather; Waterproofing Leather; Weighting Tanned Leather; Preservation of Leather—Tanning Various Skins.

Part III., **Currying**—Waxed Calf: Preparation; Shaving; Stretching or Slicking; Oiling the Grain; Oiling the Flesh Side; Whitening and Graining; Waxing; Finishing; Dry Finishing; Finishing in Colour; Cost—White Calf: Finishing in White—Cow Hide for Upper Leathers: Black Cow Hide; White Cow Hide; Coloured Cow Hide—Smooth Cow Hide—Black Leather—Miscellaneous Hides: Horse; Goat; Waxed Goat Skin; Matt Goat Skin—Russia Leather: Russia Leather; Artificial Russia Leather.

Part IV., **Enamelled, Hungary and Chamoy Leather, Morocco, Parchment, Furs and Artificial Leather**—Enamelled Leather: Varnish Manufacture; Application of the Enamel; Enamelling in Colour—Hungary Leather: Preliminary; Wet Work or Preparation; Aluming; Dressing or Loft Work; Tallowing; Hungary Leather from Various Hides—Tawing; Preparatory Operations; Dressing; Dyeing Tawed Skins; Rugs—Chamoy Leather—Morocco: Preliminary Operations, Morocco Tanning; Mordants used in Morocco Manufacture; Natural Colours used in Morocco Dyeing; Artificial Colours; Different Methods of Dyeing; Dyeing with Natural Colours; Dyeing with Aniline Colours; Dyeing with Metallic Salts; Leather Printing; Finishing Morocco; Shagreen; Bronzed Leather—Gilding and Silvering; Gilding; Silvering; Nickel and Cobalt—Parchment—Furs and Furriery. Preliminary Remarks; Indigenous Furs; Foreign Furs from Hot Countries; Foreign Furs from Cold Countries; Furs from Birds' Skins; Preparation of Furs; Dressing; Colouring; Preparation of Birds' Skins; Preservation of Furs—Artificial Leather: Leather made from Scraps; Compressed Leather; American Cloth; Papier Mâché; Linoleum; Artificial Leather.

Part V., **Leather Testing and the Theory of Tanning**—Testing and Analysis of Leather: Physical Testing of Tanned Leather; Chemical Analysis—The Theory of Tanning and the other Operations of the Leather and Skin Industry: Theory of Soaking; Theory of Unhairing; Theory of Swelling; Theory of Handling; Theory of Tanning; Theory of the Action of Tannin on the Skin; Theory of Hungary Leather Making; Theory of Tawing; Theory of Chamoy Leather Making; Theory of Mineral Tanning.

Part VI., **Uses of Leather**—Machine Belts: Manufacture of Belting; Leather Chain Belts; Various Belts; Use of Belts—Boot and Shoe-making: Boots and Shoes; Laces—Saddlery: Composition of a Saddle; Construction of a Saddle—Harness: The Pack Saddle; Harness—Military Equipment—Glove Making—Carriage Building—Mechanical Uses.

Appendix, **The World's Commerce in Leather**—Europe; America; Asia; Africa; Australasia—Index.

THE LEATHER WORKER'S MANUAL. Being a Compendium of Practical Recipes and Working Formulæ for Curriers, Bootmakers, Leather Dressers, Blacking Manufacturers, Saddlers, Fancy Leather Workers. By H. C. STANDAGE. Demy 8vo. 165 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Blackings, Polishes, Glosses, Dressings, Renovators, etc., for Boot and Shoe Leather—Harness Blackings, Dressings, Greases, Compositions, Soaps, and Boot-top Powders and Liquids, etc., etc.—Leather Grinders' Sundries—Carrier's Seasonings, Blacking Compounds, Dressings, Finishes, Glosses, etc.—Dyes and Stains for Leather—Miscellaneous Information—Chrome Tannage—Index.

Books on Pottery, Bricks, Tiles, Glass, etc.

THE MANUAL OF PRACTICAL POTTING. Compiled by Experts, and Edited by CHAS. F. BINNS. Revised Third Edition and Enlarged. 200 pp. Price 17s. 6d. net. (Post free, 17s. 10d. home; 18s. 3d. abroad.)

Contents.

Introduction. The Rise and Progress of the Potter's Art—**Bodies.** China and Porcelain Bodies, Parian Bodies, Semi-porcelain and Vitreous Bodies, Mortar Bodies, Earthenwares Granite and C.C. Bodies, Miscellaneous Bodies, Sagger and Crucible Clays, Coloured Bodies, Jasper Bodies, Coloured Bodies for Mosaic Painting, Encaustic Tile Bodies, Body Stains, Coloured Dips—**Glazes.** China Glazes, Ironstone Glazes, Earthenware Glazes, Glazes without Lead, Miscellaneous Glazes, Coloured Glazes, Majolica Colours—**Gold and Gold Colours.** Gold, Purple of Cassius, Marone and Ruby, Enamel Coloured Bases, Enamel Colour Fluxes, Enamel Colours, Mixed Enamel Colours, Antique and Vellum Enamel Colours, Underglaze Colours, Underglaze Colour Fluxes, Mixed Underglaze Colours, Flow Powders, Oils and Varnishes—**Means and Methods.** Reclamation of Waste Gold. The Use of Cobalt, Notes on Enamel Colours, Liquid or Bright Gold—**Classification and Analysis.** Classification of Clay Ware, Lord Playfair's Analysis of Clays, The Markets of

the World, Time and Scale of Firing, Weights of Potter's Material, Decorated Goods Count—Comparative Loss of Weight of Clays—Ground Felspar Calculations—The Conversion of Slop Body Recipes into Dry Weight—The Cost of Prepared Earthenware Clay—**Forms and Tables.** Articles of Apprenticeship, Manufacturer's Guide to Stocktaking, Table of Relative Values of Potter's Materials, Hourly Wages Table, Workman's Settling Table, Comparative Guide for Earthenware and China Manufacturers in the use of Slop Flint and Slop Stone, Foreign Terms applied to Earthenware and China Goods, Table for the Conversion of Metrical Weights and Measures on the Continent and South America—**Index.**

CERAMIC TECHNOLOGY: Being some Aspects of Technical Science as Applied to Pottery Manufacture. Edited by CHARLES F. BINNS. 100 pp. Demy 8vo. Price 12s. 6d. net. (Post free, 12s. 10d. home; 13s. abroad.)

Contents.

Preface—The Chemistry of Pottery — Analysis and Synthesis — Clays and their Components — The Biscuit Oven — Pyrometry — Glazes and their Composition — Colours and Colour-making—**Index.**

A TREATISE ON THE CERAMIC INDUSTRIES. A

Complete Manual for Pottery, Tile and Brick Works. By EMILE BOURRY. Translated from the French by WILTON P. RIX, Examiner in Pottery and Porcelain to the City and Guilds of London Technical Institute, Pottery Instructor to the Hanley School Board. Royal 8vo. 760 pp. 323 Illustrations. Price 21s. net. (Post free, 22s. home; 24s. abroad.)

Contents.

Part I., **General Pottery Methods.** Definition and History. Definitions and Classification of Ceramic Products—Historic Summary of the Ceramic Art—Raw Materials of Bodies. Clays: Pure Clay and Natural Clays—Various Raw Materials: Analogous to Clay—Agglomerative and Agglutinative—Opening—Fusible—Refractory—Trials of Raw Materials—Plastic Bodies. Properties and Composition—Preparation of Raw Materials: Disaggregation—Purification—Preparation of Bodies: By Plastic Method—By Dry Method—By Liquid Method—Formation. Processes of Formation: Throwing—Expression—Moulding by Hand, on the Jolley, by Compression, by Slip Casting—Slapping—Slipping—Drying. Drying of Bodies—Processes of Drying: By Evaporation—By Aeration—By Heating—By Ventilation—By Absorption—Glazes. Composition and Properties—Raw Materials—Manufacture and Application—Firing. Properties of the Bodies and Glazes during Firing—Description of the Kilns—Working of the Kilns—Decoration. Colouring Materials—Processes of Decoration.

Part II., **Special Pottery Methods.** Terra Cottas. Classification: Plain Ordinary, Hollow, Ornamental, Vitrified, and Light Bricks—Ordinary and Black Tiles—Paving Tiles—Pipes—Architectural Terra Cottas—Vases, Statues and Decorative Objects—Common Pottery—Pottery for Water and Filters—Tobacco Pipes—Lustre Ware—Properties and Tests for Terra Cottas—Fireclay Goods. Classification: Argillaceous, Aluminous, Carboniferous, Silicious and Basic Fireclay Goods—Fireclay Mortar (Pug)—Tests for Fireclay Goods—Faïences. Varnished Faïences—Enamelled Faïences—Silicious Faïences—Pipeclay Faïences—Pebble Work—Feldspathic Faïences—Composition, Processes of Manufacture and General Arrangements of Faïence Potteries—Stoneware. Stoneware Properly So-called: Paving Tiles—Pipes—Sanitary Ware—Stoneware for Food Purposes and Chemical Productions—Architectural Stoneware—Vases, Statues and other Decorative Objects—Fine Stoneware—Porcelain. Hard Porcelain for Table Ware and Decoration, for the Fire, for Electrical Conduits, for Mechanical Purposes; Architectural Porcelain, and Dull or Biscuit Porcelain—Soft Phosphated or English Porcelain—Soft Vitreous Porcelain, French and New Sèvres—Argillaceous Soft or Seger's Porcelain—Dull Soft or Parian Porcelain—Dull Feldspathic Soft Porcelain—**Index.**

POTTERY DECORATING. By R. HAINBACH. Translated from the German. Crown 8vo. 22 Illustrations. Deals with Glazes, Colours, etc. [*In the Press.*]

ARCHITECTURAL POTTERY. Bricks, Tiles, Pipes, Enamelled Terra-cottas, Ordinary and Incrusted Quarries, Stoneware Mosaics, Faïences and Architectural Stoneware. By LEON LEFÈVRE. With Five Plates. 950 Illustrations in the Text, and numerous estimates. 500 pp., royal 8vo. Translated from the French by K. H. BIRD, M.A., and W. MOORE BINNS. Price 15s. net. (Post free, 15s. 6d. home; 16s. 6d. abroad.)

Contents.

Part I. **Plain Undecorated Pottery.**—Clays, Bricks, Tiles, Pipes, Chimney Flues, Terra-cotta.

Part II. **Made-up or Decorated Pottery.**

THE ART OF RIVETING GLASS, CHINA AND EARTHENWARE. By J. HOWARTH. Second Edition. Paper Cover. Price 1s. net; by post, home or abroad, 1s. 1d.

NOTES ON POTTERY CLAYS. Their Distribution, Properties, Uses and Analyses of Ball Clays, China Clays and China Stone. By JAS. FAIRIE, F.G.S. 132 pp. Crown 8vo. Price 3s. 6d. net. (Post free, 3s. 9d. home; 3s. 10d. abroad.)

A Reissue of

THE HISTORY OF THE STAFFORDSHIRE POTTERIES; AND THE RISE AND PROGRESS OF THE MANUFACTURE OF POTTERY AND PORCELAIN.

With References to Genuine Specimens, and Notices of Eminent Pottery. By SIMEON SHAW. (Originally Published in 1829.) 265 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. 3d. abroad.)

Contents.

Introductory Chapter showing the position of the Pottery Trade at the present time (1899)—**Preliminary Remarks—The Potteries**, comprising Tunstall, Brownhills, Greenfield and New Field, Golden Hill, Latebrook, Green Lane, Burslem, Longport and Dale Hall, Hot Lane and Cobridge, Hanley and Shelton, Etruria, Stoke, Penkhull, Fenton, Lane Delph, Foley, Lane End—**On the Origin of the Art**, and its Practice among the early Nations—**Manufacture of Pottery**, prior to 1700—**The Introduction of Red Porcelain** by Messrs. Elers, of Bradwell, 1690—**Progress of the Manufacture** from 1700 to Mr. Wedgwood's commencement in 1760—**Introduction of Fluid Glaze**—Extension of the Manufacture of Cream Colour—Mr. Wedgwood's Queen's Ware—Jasper, and Appointment of Potter to Her Majesty—Black Printing—**Introduction of Porcelain**. Mr. W. Littler's Porcelain—Mr. Cookworthy's Discovery of Kaolin and Petuntse, and Patent—Sold to Mr. Champion—resold to the New Hall Com.—Extension of Term—**Blue Printed Pottery**. Mr. Turner, Mr. Spode (1), Mr. Baddeley, Mr. Spode (2), Messrs. Turner, Mr. Wood, Mr. Wilson, Mr. Minton—Great Change in Patterns of Blue Printed—**Introduction of Lustre Pottery**. Improvements in Pottery and Porcelain subsequent to 1800.

A Reissue of

THE CHEMISTRY OF THE SEVERAL NATURAL AND ARTIFICIAL HETEROGENEOUS COMPOUNDS USED IN MANUFACTURING PORCELAIN, GLASS AND POTTERY. By SIMEON SHAW.

(Originally published in 1837.) 750 pp. Royal 8vo. Price 14s. net. (Post free, 15s. home; 17s. abroad.)

Glassware, Glass Staining and Painting.

RECIPES FOR FLINT GLASS MAKING. By a British Glass Master and Mixer. Sixty Recipes. Being Leaves from the Mixing Book of several experts in the Flint Glass Trade, containing up-to-date recipes and valuable information as to Crystal, Demi-crystal and Coloured Glass in its many varieties. It contains the recipes for cheap metal suited to pressing, blowing, etc., as well as the most costly crystal and ruby. Crown 8vo. Price 10s. 6d. net. (Post free, 10s. 9d. home; 10s. 10d. abroad.)

Contents.

Ruby—Ruby from Copper—Flint for using with the Ruby for Coating—A German Metal—Cornelian, or Alabaster—Sapphire Blue—Crysophis—Opal—Turquoise Blue—Gold Colour—Dark Green—Green (common)—Green for Malachite—Blue for Malachite—Black for Malachite—Black—Common Canary Batch—Canary—White Opaque Glass—Sealing-wax Red—Flint—Flint Glass (Crystal and Demi)—Achromatic Glass—Paste Glass—White Enamel—Firestone—Dead White (for moons)—White Agate—Canary—Canary Enamel—Index.

A TREATISE ON THE ART OF GLASS PAINTING.

Prefaced with a Review of Ancient Glass. By ERNEST R. SUFFLING. With One Coloured Plate and Thirty-seven Illustrations. Demy 8vo. 140 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home ; 8s. abroad.)

Contents.

A Short History of Stained Glass—Designing Scale Drawings—Cartoons and the Cut Line—Various Kinds of Glass Cutting for Windows—The Colours and Brushes used in Glass Painting—Painting on Glass, Dispersed Patterns—Diapered Patterns—Aciding—Firing—Fret Lead Glazing—Index.

PAINTING ON GLASS AND PORCELAIN AND ENAMEL PAINTING.

A Complete Introduction to the Preparation of all the Colours and Fluxes used for Painting on Porcelain, Enamel, Faience and Stoneware, the Coloured Pastes and Coloured Glasses, together with a Minute Description of the Firing of Colours and Enamels. By FELIX HERMANN, Technical Chemist. With Eighteen Illustrations. 300 pp. Translated from the German second and enlarged Edition. Price 10s. 6d. net. (Post free, 10s. 10d. home ; 11s. abroad.)

Paper Making, Paper Dyeing, and Testing.

THE DYEING OF PAPER PULP. A Practical Treatise for the use of Papermakers, Paperstainers, Students and others. By JULIUS ERFURT, Manager of a Paper Mill. Translated into English and Edited with Additions by JULIUS HÜBNER, F.C.S., Lecturer on Papermaking at the Manchester Municipal Technical School. With Illustrations and **157 patterns of paper dyed in the pulp.** Royal 8vo, 180 pp. Price 15s. net. (Post free, 15s. 6d. home ; 16s. 6d. abroad.)

Contents.

Behaviour of the Paper Fibres during the Process of Dyeing, Theory of the Mordant—Colour Fixing Mediums (Mordants)—Influence of the Quality of the Water Used—Inorganic Colours—Organic Colours—Practical Application of the Coal Tar Colours according to their Properties and their Behaviour towards the Different Paper Fibres—Dyed Patterns on Various Pulp Mixtures—Dyeing to Shade—Index.

THE PAPER MILL CHEMIST. By HENRY P. STEVENS, M.A., Ph.D., F.I.C. Royal 12mo. 60 Illustrations. [*In the press.*]

Contents.

Introduction.—Dealing with the Apparatus required in Chemical Work and General Chemical Manipulation, introducing the subject of Qualitative and Quantitative Analysis. **Fuels.**—Analysis of Coal, Coke and other Fuels—Sampling and Testing for Moisture, Ash, Calorific Value, etc.—Comparative Heating Value of different Fuels and Relative Efficiency. **Water.**—Analysis for Steam Raising and for Paper Making Purposes generally—Water Softening and Purification—A List of the more important Water Softening Plant, giving Power required, Weight, Space Occupied, Out-put and Approximate Cost. **Raw Materials and Detection of Adulterants.**—Analysis and Valuation of the more important Chemicals used in Paper Making, including Lime, Caustic Soda, Sodium Carbonate, Mineral Acids, Bleach Antichlor, Alum, Rosin and Rosin Size, Glue Gelatin and Casein, Starch, China Clay, Blanc Fixe, Satin White and other Loading Materials, Mineral Colours and Aniline Dyes. **Manufacturing Operations.**—Rags and the Chemical Control of Rag Boiling—Esparto Boiling—Wood Boiling—Testing Spent Liquors and Recovered Ash—Experimental Tests with Raw Fibrous Materials—Boiling in Autoclaves—Bleaching and making up Hand Sheets—Examination of Sulphite Liquors—Estimation of Moisture in Pulp and Half-stuff—Recommendations of the British Wood Pulp Association. **Finished Products.**—Paper Testing, including Physical, Chemical and Microscopical Tests, Area, Weight, Thickness, Apparent Specific Gravity, Bulk or Air Space. Determination of Machine Direction, Thickness, Strength, Stretch, Resistance to Crumpling and Friction, Transparency, Absorbency and other qualities of Blotting Papers—Determination of the Permeability of Filtering Papers—Detection and Estimation of Animal and Vegetable Size in Paper—Sizing Qualities of Paper—Fibrous Constituents—Microscopical Examination of Fibres—The Effect of Beating on Fibres—Staining Fibres—Mineral Matter—Ash—Qualitative and Quantitative Examination of Mineral Matter—Examination of Coated Papers and Colouring Matters in Paper.

CONTENTS OF "THE TESTING OF PAPER"—*continued.*

Tables.—English and Metrical Weights and Measures with Equivalents—Conversion of Grams to Grains and *vice versa*—Equivalent Costs per lb., cwt., and ton—Decimal Equivalents of lbs., qrs., and cwt.—Thermometric and Barometric Scales—Atomic Weights and Molecular Weights—Factors for Calculating the Percentage of Substance Sought from the Weight of Substance Found—Table of Solubilities of Substances Treated of in Paper Making—Specific Gravity Tables of such substances as are used in Paper Making, including Sulphuric Acid, Hydrochloric Acid, Bleach, Milk of Lime, Caustic Soda, Carbonate of Soda, etc., giving Percentage Strength with Specific Gravity and Degrees Tw.—Hardness Table for Soap Tests—Dew Point—Wet and Dry Bulb Tables—Properties of Saturated Steam, giving Temperature, Pressure and Volume—List of Different Machines used in the Paper Making Industry, giving Size, Weight, Space Occupied, Power to Drive, Out-put and Approximate Cost—Calculation of Moisture in Pulp—Rag-Boiling Tables, giving Percentages of Lime, Soda and Time required—Loss in Weight in Rags and other Raw Materials during Boiling and Bleaching—Conditions of Buying and Selling as laid down by the Paper Makers' Association—Table of Names and Sizes of Papers—Table for ascertaining the Weight per Ream from the Weight per Sheet—Calculations of Areas and Volumes—Logarithms—Blank pages for Notes.

THE TREATMENT OF PAPER FOR SPECIAL PURPOSES. By L. E. ANDÉS. Translated from the German. Crown 8vo. 48 Illustrations. 250 pp. *[In the Press.]*

Contents.

I., **Parchment Paper, Vegetable Parchment.**—The Parchment Paper Machine—Opaque Supple Parchment Paper—Thick Parchment—Krugler's Parchment Paper and Parchment Slates—Double and Triple Osmotic Parchment—Utilising Waste Parchment Paper—Parchmented Linen and Cotton—Parchment Millboard—Imitation Horn and Ivory from Parchment Paper—Imitation Parchment Paper—Artificial Parchment—Testing the Sulphuric Acid. II., **Papers for Transfer Pictures.** III., **Papers for Preservative and Packing Purposes.**—Butter Paper—Wax Paper—Paraffin Paper—Wrapping Paper for Silverware—Waterproof Paper—Anticorrosive Paper. IV., **Grained Transfer Papers.** V., **Fireproof and Antifalsification Papers.** VI., **Paper Articles.**—Vulcanised Paper Maché—Paper Bottles—Plastic Articles of Paper—Waterproof Coverings for Walls and Ceilings—Paper Wheels, Roofing and Boats—Paper Barrels—Paper Boxes—Paper Horseshoes. VII., **Gummed Paper.** VIII., **Hectograph Papers.** IX., **Insecticide Papers.**—Fly Papers—Moth Papers. X., **Chalk and Leather Papers.**—Glacé Chalk Paper—Leather Paper—Imitation Leather. XI., **Luminous Papers.**—Blue-Print Papers—Blotting Papers. XII., **Metal Papers.**—Medicated Papers. XIII., **Marbled Papers.** XIV., **Tracing and Copying Papers.**—Iridescent or Mother of Pearl Papers. XV., **Photographic Papers.**—Shellac Paper—Fumigating Papers—Test Papers. XVI., **Papers for Cleaning and Polishing Purposes.**—Glass Paper—Pumic Paper—Emery Paper. XVII., **Lithographic Transfer Papers.** XIX., **Sundry Special Papers.**—Satin Paper—Enamel Paper—Cork Paper—Split Paper—Electric Paper—Paper Matches—Magic Pictures—Laundry Blue Papers—Blue Paper for Bleachers. XX., **Waterproof Papers.**—Washable Drawing Papers—Washable Card—Washable Coloured Paper—Waterproof Millboard—Sugar Paper. XXI., **The Characteristics of Paper.**—Paper Testing.

Enamelling on Metal.

ENAMELS AND ENAMELLING. For Enamel Makers, Workers in Gold and Silver, and Manufacturers of Objects of Art. By PAUL RANDAU. Translated from the German. With Sixteen Illustrations. Demy 8vo. 180 pp. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. abroad.)

THE ART OF ENAMELLING ON METAL. By W. NORMAN BROWN. Twenty-eight Illustrations. Crown 8vo. 60 pp. Price 2s. 6d. net. (Post free, 2s. 9d. home and abroad.)

Silk Manufacture.

SILK THROWING AND WASTE SILK SPINNING. By HOLLINS RAYNER. Demy 8vo. 170 pp. 117 Illus. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

The Silkworm—Cocoon Reeling and Qualities of Silk—Silk Throwing—Silk Wastes—The Preparation of Silk Waste for Degumming—Silk Waste Degumming, Schapping and Discharging—The Opening and Dressing of Wastes—Silk Waste "Drawing" or "Preparing" Machinery—Long Spinning—Short Spinning—Spinning and Finishing Processes—Utilisation of Waste Products—Noil Spinning—Exhaust Noil Spinning.

Books on Textile and Dyeing Subjects.

THE CHEMICAL TECHNOLOGY OF TEXTILE

FIBRES: Their Origin, Structure, Preparation, Washing, Bleaching, Dyeing, Printing and Dressing. By Dr. GEORG VON GEORGIEVICS. Translated from the German by CHARLES SALTER. 320 pp. Forty-seven Illustrations. Royal 8vo. Price 10s. 6d. net. (Post free, 11s. home; 11s. 3d. abroad.)

Contents.

The Textile Fibres—Washing, Bleaching, Carbonising—Mordants and Mordanting—Dyeing—Printing—Dressing and Finishing.

POWER-LOOM WEAVING AND YARN NUMBERING,

According to Various Systems, with Conversion Tables. Translated from the German of ANTHON GRUNER. **With Twenty-six Diagrams in Colours.** 150 pp. Crown 8vo. Price 7s. 6d. net. (Post free, 7s. 9d. home; 8s. abroad.)

Contents.

Power-Loom Weaving in General. Various Systems of Looms—Mounting and Starting the Power-Loom. English Looms—Tappet or Treadle Looms—Dobbies—General Remarks on the Numbering, Reeling and Packing of Yarn—Appendix—Useful Hints. Calculating Warps—Weft Calculations—Calculations of Cost Price in Hanks.

TEXTILE RAW MATERIALS AND THEIR CONVERSION INTO YARNS.

(The Study of the Raw Materials and the Technology of the Spinning Process.) By JULIUS ZIPSER. Translated from German by CHARLES SALTER. 302 Illustrations. 500 pp. Demy 8vo. Price 10s. 6d. net. (Post free, 11s. home; 11s. 6d. abroad.)

Contents.

PART I.—The Raw Materials Used in the Textile Industry.

MINERAL RAW MATERIALS. VEGETABLE RAW MATERIALS. ANIMAL RAW MATERIALS.

PART II.—The Technology of Spinning or the Conversion of Textile Raw Materials into Yarn.

SPINNING VEGETABLE RAW MATERIALS. Cotton Spinning—Installation of a Cotton Mill—Spinning Waste Cotton and Waste Cotton Yarns—Flax Spinning—Fine Spinning—Tow Spinning—Hemp Spinning—Spinning Hemp Tow String—Jute Spinning—Spinning Jute Line Yarn—Utilising Jute Waste.

PART III.—Spinning Animal Raw Materials.

Spinning Carded Woollen Yarn—Finishing Yarn—Worsted Spinning—Finishing Worsted Yarn—Artificial Wool or Shoddy Spinning—Shoddy and Mungo Manufacture—Spinning Shoddy and other Wool Substitutes—Spinning Waste Silk—Chappe Silk—Fine Spinning—Index.

GRAMMAR OF TEXTILE DESIGN. By H. NISBET,

Weaving and Designing Master, Bolton Municipal Technical School. Demy 8vo. 280 pp. 490 Illustrations and Diagrams. Price 6s. net. (Post free, 6s. 10d. home; 7s. abroad.)

Contents.

Chapter I., INTRODUCTION.—General Principle of Fabric Structure and the use of Design Paper.

Chapter II., THE PLAIN WEAVE AND ITS MODIFICATIONS.—The Plain, Calico, or Tabby Weave.—Firmness of Texture—Variety of Texture—Variety of Form: Ribbed Fabrics—Corded Fabrics—Matt Weaves.

Chapter III., TWILL AND KINDRED WEAVES.—Classification of Twill Weaves.—1. Continuous Twills—(a) Warp-face Twills—(b) Weft-face Twills—(c) Warp and Weft-face Twills—The Angle of Twill—Influences affecting the Prominence of Twills and Kindred Weaves (a) Character of Weave, (b) Character of Yarn, (c) Number of Threads per Inch, (d) Direction of Twill in Relation to the Direction of Twist in Yarn.—2. Zigzag or Wavy Twills.—3. Re-arranged Twills: Satin Weaves—Table of Intervals of Selection for the Construction of Satin Weaves—Corkscrew Twills—Rearrangement of Twill Weaves on Satin and other Bases.—4. Combined Twills.—5. Broken Twills.—6. Figured or Ornamented Twills.

Chapter IV., DIAMOND AND KINDRED WEAVES.—Diamond Weaves.—Honeycomb and Kindred Weaves—Brighton Weaves—Sponge Weaves—Huck-a-Back and Kindred Weaves—Grecian Weaves—Linear Zigzag Weaves.

[Continued on next page.]

CONTENTS OF "GRAMMAR OF TEXTILE DESIGN"—

continued.

Chapter V., BEDFORD CORDS.—Plain Calico-ribbed Bedford Cords—Plain Twill-ribbed Bedford Cords—Figured Bedford Cords—Tabulated Data of Particulars relating to the Manufacture of Seventeen Varieties of Bedford Cord Fabrics described in this Chapter.

Chapter VI., BACKED FABRICS.—Weft-backed Fabrics—Warp-backed Fabrics—Reversible or Double-faced Fabrics.

Chapter VII., FUSTIANS.—Varieties of Fustians.—Imperials or Swansdowns—Cantons or Diagonals—Moleskins—Beaverteens—Velveteens and Velveteen Cutting—Ribbed or Corded Velveteen—Figured Velveteen—Corduroy—Figured Corduroy—Corduroy Cutting Machines.

Chapter VIII., TERRY PILE FABRICS.—Methods of producing Terry Pile on Textile Fabrics—Terry-forming Devices—Varieties of Terry Fabrics—Action of the Reed in Relation to Shedding—Figured Terry Weaving—Practical Details of Terry Weaving.

Chapter IX., GAUZE AND LENO FABRICS.—Gauze, Net Leno, and Leno Brocade Varieties of Cross-Weaving.—Plain Gauze, and a Heald Gauze or Leno Harness—Net Leno Fabrics—Gauze and Net Leno Figuring by means of several Back Standard Healds to each Doup Heald—Leno Specialities produced by a System of Crossing Warp Ends in front of the Reed—A Device for the Production of Special Leno Effects—Full Cross Leno Fabrics—Relative Merits of a Top and a Bottom Doup Harness—Relative Merits of Different Types of Dobbies for Gauze and Leno Fabrics—Shaking Devices for Leno Weaving—Practical Details of Leno Weaving—Tempered Steel-wire Doup Harnesses for Cross-weaving—Mock or Imitation Leno Fabrics.

Chapter X., TISSUE, LAPPET, AND SWIVEL FIGURING; ALSO ONDULÉ EFFECTS, AND LOOPED FABRICS.—Tissue Figuring—Madras Muslin Curtains—Lappet Figuring—Spot Lappet Figuring—Swivel Figuring—Woven Ondulé Effects—Loom for Weaving Ondulé Effects—Weft Ondulé Effects—Looped Fabrics.—INDEX.

NEEDLEWORK AND DESIGN. By Miss M. E. WILKINSON. Quarto. 24 Plates and Text. 52 pp. *[In the Press.]*

HOME LACE-MAKING. A Handbook for Teachers and Pupils. By M. E. W. MILROY. Crown 8vo. 64 pp. With 3 Plates and 9 Diagrams. Price 1s. net. (Post free, 1s. 3d. home; 1s. 4d. abroad.)

THE CHEMISTRY OF HAT MANUFACTURING. Lectures delivered before the Hat Manufacturers' Association. By WATSON SMITH, F.C.S., F.I.C. Revised and Edited by ALBERT SHONK. Crown 8vo. 132 pp. 16 Illustrations. Price 7s. 6d. net. (Post free, 7s. 9d. home; 7s. 10d. abroad.)

Contents.

Textile Fibres, principally Wool, Fur, and Hair—Water: its Chemistry and Properties; Impurities and their Action; Tests of Purity—Acids and Alkalis—Boric Acid, Borax, Soap—Shellac, Wood Spirit, and the Stiffening and Proofing Process—Mordants: their Nature and Use—Dyestuffs and Colours—Dyeing of Wool and Fur; and Optical Properties of Colours—Index.

THE TECHNICAL TESTING OF YARNS AND TEXTILE FABRICS. With Reference to Official Specifications. Translated from the German of Dr. J. HERZFELD. Second Edition. Sixty-nine Illustrations. 200 pp. Demy 8vo. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. abroad.)

Contents.

Yarn Testing. Determining the Yarn Number—Testing the Length of Yarns—Examination of the External Appearance of Yarn—Determining the Twist of Yarn and Twist—Determination of Tensile Strength and Elasticity—Estimating the Percentage of Fat in Yarn—Determination of Moisture (Conditioning)—Appendix.

DECORATIVE AND FANCY TEXTILE FABRICS.

By R. T. LORD. Manufacturers and Designers of Carpets, Damask, Dress and all Textile Fabrics. 200 pp. Demy 8vo. 132 Designs and Illustrations. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

THEORY AND PRACTICE OF DAMASK WEAVING.

By H. KINZER and K. WALTER. Royal 8vo. Eighteen Folding Plates. Six Illustrations. Translated from the German. 110 pp. Price 8s. 6d. net. (Post free, 9s. home; 9s. 6d. abroad.)

TEXTILE BOOKS—*continued.*

Contents.

The Various Sorts of Damask Fabrics—Drill (Ticking, Handloom-made)—Whole Damask for Tablecloths—Damask with Ground- and Connecting-warp Threads—Furniture Damask—Lampas or Hangings—Church Damasks—**The Manufacture of Whole Damask**—Damask Arrangement with and without Cross-Shedding—The Altered Cone-arrangement—The Principle of the Corner Lifting Cord—The Roller Principle—The Combination of the Jacquard with the so-called Damask Machine—The Special Damask Machine—The Combination of Two Tyings.

FAULTS IN THE MANUFACTURE OF WOOLLEN GOODS AND THEIR PREVENTION. By NICOLAS

REISER. Translated from the Second German Edition. Crown 8vo. Sixty-three Illustrations. 170 pp. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

Improperly Chosen Raw Material or Improper Mixtures—Wrong Treatment of the Material in Washing, Carbonisation, Drying, Dyeing and Spinning—Improper Spacing of the Goods in the Loom—Wrong Placing of Colours—Wrong Weight or Width of the Goods—Breaking of Warp and Weft Threads—Presence of Doubles, Singles, Thick, Loose, and too Hard Twisted Threads as well as Tangles, Thick Knots and the Like—Errors in Cross-weaving—Inequalities, *i.e.*, Bands and Stripes—Dirty Borders—Defective Selvedges—Holes and Buttons—Rubbed Places—Creases—Spots—Loose and Bad Colours—Badly Dyed Selvedges—Hard Goods—Brittle Goods—Uneven Goods—Removal of Bands, Stripes, Creases and Spots.

SPINNING AND WEAVING CALCULATIONS, especially relating to Woollens. From the German of N. REISER. Thirty-four Illustrations. Tables. 160 pp. Demy 8vo. 1904. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. abroad.)

Contents.

Calculating the Raw Material—Proportion of Different Grades of Wool to Furnish a Mixture at a Given Price—Quantity to Produce a Given Length—Yarn Calculations—Yarn Number—Working Calculations—Calculating the Reed Count—Cost of Weaving, etc.

WATERPROOFING OF FABRICS. By Dr. S. MIERZINSKI. Crown 8vo. 104 pp. 29 Illus. Price 5s. net. (Post free, 5s. 3d. home; 5s. 4d. abroad.)

Contents.

Introduction—Preliminary Treatment of the Fabric—Waterproofing with Acetate of Alumina—Impregnation of the Fabric—Drying—Waterproofing with Paraffin—Waterproofing with Ammonium Cuprate—Waterproofing with Metallic Oxides—Coloured Waterproof Fabrics—Waterproofing with Gelatine, Tannin, Caseinate of Lime and other Bodies—Manufacture of Tarpaulin—British Waterproofing Patents—Index.

HOW TO MAKE A WOOLLEN MILL PAY. By JOHN MACKIE. Crown 8vo. 76 pp. Price 3s. 6d. net. (Post free, 3s. 9d. home; 3s. 10d. abroad.)

Contents.

Blends, Piles, or Mixtures of Clean Scoured Wools—Dyed Wool Book—The Order Book—Pattern Duplicate Books—Management and Oversight—Constant Inspection of Mill Departments—Importance of Delivering Goods to Time, Shade, Strength, etc.—Plums.

(For "Textile Soaps and Oils" see p. 7.)

Dyeing, Colour Printing, Matching and Dye-stuffs.

THE COLOUR PRINTING OF CARPET YARNS. Manual for Colour Chemists and Textile Printers. By DAVID PATERSON, F.C.S. Seventeen Illustrations. 136 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Structure and Constitution of Wool Fibre—Yarn Scouring—Scouring Materials—Water for Scouring—Bleaching Carpet Yarns—Colour Making for Yarn Printing—Colour Printing Pastes—Colour Recipes for Yarn Printing—Science of Colour Mixing—Matching of Colours—"Hank" Printing—Printing Tapestry Carpet Yarns—Yarn Printing—Steaming Printed Yarns—Washing of Steamed Yarns—Aniline Colours Suitable for Yarn Printing—Glossary of Dyes and Dye-wares used in Wood Yarn Printing—Appendix.

THE SCIENCE OF COLOUR MIXING. A Manual intended for the use of Dyers, Calico Printers and Colour Chemists. By DAVID PATERSON, F.C.S. Forty-one Illustrations, **Five Coloured Plates, and Four Plates showing Eleven Dyed Specimens of Fabrics.** 132 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Colour a Sensation; Colours of Illuminated Bodies; Colours of Opaque and Transparent Bodies; Surface Colour—Analysis of Light; Spectrum; Homogeneous Colours; Ready Method of Obtaining a Spectrum—Examination of Solar Spectrum; The Spectroscope and Its Construction; Colourists' Use of the Spectroscope—Colour by Absorption; Solutions and Dyed Fabrics; Dichroic Coloured Fabrics in Gaslight—Colour Primaries of the Scientist *versus* the Dyer and Artist; Colour Mixing by Rotation and Lye Dyeing; Hue, Purity, Brightness; Tints; Shades, Scales, Tones, Sad and Sombre Colours—Colour Mixing; Pure and Impure Greens, Orange and Violets; Large Variety of Shades from few Colours; Consideration of the Practical Primaries: Red, Yellow and Blue—Secondary Colours; Nomenclature of Violet and Purple Group; Tints and Shades of Violet; Changes in Artificial Light—Tertiary Shades; Broken Hues; Absorption Spectra of Tertiary Shades—Appendix: Four Plates with Dyed Specimens Illustrating Text—Index.

DYERS' MATERIALS: An Introduction to the Examination, Evaluation and Application of the most important Substances used in Dyeing, Printing, Bleaching and Finishing. By PAUL HEERMAN, Ph.D. Translated from the German by A. C. WRIGHT, M.A. (Oxon.), B.Sc. (Lond.). Twenty-four Illustrations. Crown 8vo. 150 pp. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

COLOUR MATCHING ON TEXTILES. A Manual intended for the use of Students of Colour Chemistry, Dyeing and Textile Printing. By DAVID PATERSON, F.C.S. Coloured Frontispiece. Twenty-nine Illustrations and **Fourteen Specimens of Dyed Fabrics.** Demy 8vo. 132 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Colour Vision and Structure of the Eye—Perception of Colour—Primary and Complementary Colour Sensations—Daylight for Colour Matching—Selection of a Good Pure Light—Diffused Daylight, Direct Sunlight, Blue Skylight, Variability of Daylight, etc., etc.—Matching of Hues—Purity and Luminosity of Colours—Matching Bright Hues—Aid of Tinted Films—Matching Difficulties Arising from Contrast—Examination of Colours by Reflected and Transmitted Lights—Effect of Lustre and Transparency of Fibres in Colour Matching—Matching of Colours on Velvet Pile—Optical Properties of Dye-stuffs, Dichroism, Fluorescence—Use of Tinted Mediums—Orange Film—Defects of the Eye—Yellowing of the Lens—Colour Blindness, etc.—Matching of Dyed Silk Trimmings and Linings and Bindings—Its Difficulties—Behaviour of Shades in Artificial Light—Colour Matching of Old Fabrics, etc.—Examination of Dyed Colours under the Artificial Lights—Electric Arc, Magnesium and Dufton, Gardner Lights, Welsbach, Acetylene, etc.—Testing Qualities of an Illuminant—Influence of the Absorption Spectrum in Changes of Hue under the Artificial Lights—Study of the Causes of Abnormal Modifications of Hue, etc.

COLOUR: A HANDBOOK OF THE THEORY OF COLOUR. By GEORGE H. HURST, F.C.S. **With Ten Coloured Plates** and Seventy-two Illustrations. 160 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Colour and Its Production—Cause of Colour in Coloured Bodies—Colour Phenomena and Theories—The Physiology of Light—Contrast—Colour in Decoration and Design—Measurement of Colour.

Reissue of

THE ART OF DYEING WOOL, SILK AND COTTON. Translated from the French of M. HELLOT, M. MACQUER and M. LE PILEUR D'APLIGNY. First Published in English in 1789. Six Plates. Demy 8vo. 446 pp. Price 5s. net. (Post free, 5s. 6d. home; 6s. abroad.)

Contents.

Part I., The Art of Dyeing Wool and Woollen Cloth, Stuffs, Yarn, Worsted, etc. Part II., The Art of Dyeing Silk. Part III., The Art of Dyeing Cotton and Linen Thread, together with the Method of Stamping Silks, Cottons, etc.

THE CHEMISTRY OF DYE-STUFFS. By Dr. GEORG VON GEORGIEVICS. Translated from the Second German Edition. 412 pp. Demy 8vo. Price 10s. 6d. net. (Post free, 11s. home; 11s. 6d. abroad.)

Contents.

Introduction—Coal Tar—Intermediate Products in the Manufacture of Dye-stuffs—The Artificial Dye-stuffs (Coal-tar Dyes)—Nitroso Dye-stuffs—Nitro Dye-stuffs—Azo Dye-stuffs—Substantive Cotton Dye-stuffs—Azoxystilbene Dye-stuffs—Hydrazones—Ketoneimides—Triphenylmethane Dye-stuffs—Rosolic Acid Dye-stuffs—Xanthene Dye-stuffs—Xanthone Dye-stuffs—Flavones—Oxyketone Dye-stuffs—Quinoline and Acridine Dye-stuffs—Quinonimide or Diphenylamine Dye-stuffs—The Azine Group: Eurhodines, Safranines and Indulines—Eurhodines—Safranines—Quinoxalines—Indigo—Dye-stuffs of Unknown Constitution—Sulphur or Sulphine Dye-stuffs—Development of the Artificial Dye-stuff Industry—The Natural Dye-stuffs—Mineral Colours—Index.

THE DYEING OF COTTON FABRICS: A Practical Handbook for the Dyer and Student. By FRANKLIN BEECH, Practical Colourist and Chemist. 272 pp. Forty-four Illustrations of Bleaching and Dyeing Machinery. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Structure and Chemistry of the Cotton Fibre—Scouring and Bleaching of Cotton—Dyeing Machinery and Dyeing Manipulations—Principles and Practice of Cotton Dyeing—Direct Dyeing; Direct Dyeing followed by Fixation with Metallic Salts; Direct Dyeing followed by Fixation with Developers; Direct Dyeing followed by Fixation with Couplers; Dyeing on Tannic Mordant; Dyeing on Metallic Mordant; Production of Colour Direct upon Cotton Fibres; Dyeing Cotton by Impregnation with Dye-stuff Solution—Dyeing Union (Mixed Cotton and Wool) Fabrics—Dyeing Half Silk (Cotton-Silk, Satin) Fabrics—Operations following Dyeing—Washing, Soaping, Drying—Testing of the Colour of Dyed Fabrics—Experimental Dyeing and Comparative Dye Testing—Index.

The book contains numerous recipes for the production on Cotton Fabrics of all kinds of a great range of colours.

THE DYEING OF WOOLLEN FABRICS. By FRANKLIN BEECH, Practical Colourist and Chemist. Thirty-three Illustrations. Demy 8vo. 228 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

The Wool Fibre—Structure, Composition and Properties—Processes Preparatory to Dyeing—Scouring and Bleaching of Wool—Dyeing Machinery and Dyeing Manipulations—Loose Wool Dyeing, Yarn Dyeing and Piece Dyeing Machinery—The Principles and Practice of Wool Dyeing—Properties of Wool Dyeing—Methods of Wool Dyeing—Groups of Dyes—Dyeing with the Direct Dyes—Dyeing with Basic Dyes—Dyeing with Acid Dyes—Dyeing with Mordant Dyes—Level Dyeing—Blacks on Wool—Reds on Wool—Mordanting of Wool—Orange Shades on Wool—Yellow Shades on Wool—Green Shades on Wool—Blue Shades on Wool—Violet Shades on Wool—Brown Shades on Wool—Mode Colours on Wool—Dyeing Union (Mixed Cotton Wool) Fabrics—Dyeing of Gloria—Operations following Dyeing—Washing, Soaping, Drying—Experimental Dyeing and Comparative Dye Testing—Testing of the Colour of Dyed Fabrics—Index.

Bleaching and Washing.

A PRACTICAL TREATISE ON THE BLEACHING OF LINEN AND COTTON YARN AND FABRICS. By L. TAILFER, Chemical and Mechanical Engineer. Translated from the French by JOHN GEDDES MCINTOSH. Demy 8vo. 303 pp. Twenty Illus. Price 12s. 6d. net. (Post free, 13s. home; 13s. 6d. abroad.)

Cotton Spinning and Combing.

COTTON SPINNING (First Year). By THOMAS THORNLEY, Spinning Master, Bolton Technical School. 160 pp. Eighty-four Illustrations. Crown 8vo. Second Impression. Price 3s. net. (Post free, 3s. 4d. home; 3s. 6d. abroad.)

Contents.

Syllabus and Examination Papers of the City and Guilds of London Institute—Cultivation, Classification, Ginning, Baling and Mixing of the Raw Cotton—Bale-Breakers, Mixing Lattices and Hopper Feeders—Opening and Scutching—Carding—Indexes.

COTTON SPINNING (Intermediate, or Second Year). By THOMAS THORNLEY. 180 pp. Seventy Illustrations. Crown 8vo. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

Syllabuses and Examination Papers of the City and Guilds of London Institute—The Combing Process—The Drawing Frame—Bobbin and Fly Frames—Mule Spinning—Ring Spinning—General Indexes.

COTTON SPINNING (Honours, or Third Year). By THOMAS THORNLEY. 216 pp. Seventy-four Illustrations. Crown 8vo. Second Edition. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

Syllabuses and Examination Papers of the City and Guilds of London Institute—Cotton—The Practical Manipulation of Cotton Spinning Machinery—Doubling and Winding—Reeling—Warping—Production and Costs—Main Driving—Arrangement of Machinery and Mill Planning—Waste and Waste Spinning—Indexes.

COTTON COMBING MACHINES. By THOS. THORNLEY, Spinning Master, Technical School, Bolton. Demy 8vo. 117 Illustrations. 300 pp. Price 7s. 6d. net. (Post free, 8s. home; 8s. 6d. abroad.)

Contents.

The Sliver Lap Machine and the Ribbon Cap Machine—General Description of the Heilmann Comber—The Cam Shaft—On the Detaching and Attaching Mechanism of the Comber—Resetting of Combers—The Erection of a Heilmann Comber—Stop Motions: Various Calculations—Various Notes and Discussions—Cotton Combing Machines of Continental Make—Index.

Flax, Hemp and Jute Spinning.

MODERN FLAX, HEMP AND JUTE SPINNING AND TWISTING. A Practical Handbook for the use of Flax, Hemp and Jute Spinners, Thread, Twine and Rope Makers. By HERBERT R. CARTER, Mill Manager, Textile Expert and Engineer, Examiner in Flax Spinning to the City and Guilds of London Institute. Demy 8vo. 1907. With 92 Illustrations. 200 pp. Price 7s. 6d. net. (Post free, 7s. 9d. home; 8s. abroad.)

Contents.

Raw Fibre.—Origin of Flax—Hemp and Jute Fibre—Description of the Plants—Mode of Cultivation—Suitable Climate and Soil—Sowing—Harvesting—Rippling Flax and Hemp—Water Retting—Dew Retting—Extraction of the Fibre—Marketing the Fibre—Bracquing—Flax, Hemp and Jute Marks—Comparative Prices—Ports of Export—Trade Centres—Fibre Selling Conditions—Duty on Fibre—Fibre Exports. **Hackling.**—Sorting and Storing the Raw Fibre—Softening Hemp and Jute—Jute Batching—Cutting—Piecing Out—Roughing—Hackling by Hand and Machine—Tippling—Sorting—Ventilation of Hackling Rooms. **Sliver Formation.**—Spreading Line—Heavy Spreading System—Good's Combined Hackle and Spreader—Jute Breaking and Carding—Flax and Hemp Tow Carding—Bell Calculation—Clock System—Theory of Spreading. **Line and Tow Preparing.**—Drawing and Doubling—Draft Calculation—Set Calculation—Tow Combing—Compound Systems—Automatic Stop Motions and Independent Heads—Details of Preparing Machinery—Ventilation—Humidification. **Gill Spinning.**—Gill Spinning for Shoe Threads, Rope Yarns, Binder and Trawl Twines—The Automatic Gill Spinner—Rope and Reaper Yarn Numbering. **The Flax, Hemp and Jute Roving Frame.**—Bobbin Winding—Differential Motion—Twist Calculation—Practical Changing—Rove Stock. **Dry and Half-Dry Spinning.**—Flyer and Ring Frames—Draft and Twist Calculation—Bobbin Dragging—Reaches—Set of Breast Beam and Tin-rod. **Wet Spinning** of Flax, Hemp and Tow—Hot and Cold Water Spinning—Improvements in the Water Trough—Turn off and Speed of Spindles—Reaches—Belting—Band Tying—Tape Driving—Oiling—Black Threads—Cuts per Spindle—Ventilation of the Wet Spinning Room. **Yarn Department.**—Reeling—Cop Winding—Cheese and Spool Winding—Balling Shoe Thread, Reaper Yarn, etc.—Yarn Drying and Conditioning—Yarn Bundling—Yarn Baling—Weight of Yarn—Yarn Tables—Duty on Yarn Imports. **Manufacture of Threads, Twines and Cords.**—Hank Winding—Wet and Dry Twisting—Cabling—Fancy Yarns—Twine Laying—Sizing and Polishing Threads and Twines—Softening Threads—Skeining Threads—Balling Twines—Leeson's Universal Winder—Randing Twines—Spooling Sewing Threads—Comparative Prices of Flax and Hemp Cords, Lines and Threads. **Rope Making.**—Construction of Hawfers and Cables—Stranding—Laying and Closing—Compound Rope Machines—Rules for Rope Makers—Weight of Ropes—Balling and Coiling Ropes. **Mechanical Department.**—Boilers, Engines and Turbines—Power Transmission by Belts and Ropes—Electric Light and Power Transmission—Fans—Oils and Oiling—Repairs—Fluting. **Mill Construction.**—Flax, Hemp and Jute Spinning Mills and Ropeworks—Heating—Roofs—Chimneys, etc.

Collieries and Mines.

RECOVERY WORK AFTER PIT FIRES. By ROBERT LAMPRECHT, Mining Engineer and Manager. Translated from the German. Illustrated by Six large Plates, containing Seventy-six Illustrations. 175 pp., demy 8vo. Price 10s. 6d. net. (Post free, 10s. 10d. home; 11s. abroad.)

Contents.

Causes of Pit Fires—Preventive Regulations: (1) The Outbreak and Rapid Extension of a Shaft Fire can be most reliably prevented by Employing little or no Combustible Material in the Construction of the Shaft; (2) Precautions for Rapidly Localising an Outbreak of Fire in the Shaft; (3) Precautions to be Adopted in case those under 1 and 2 Fail or Prove Inefficient. Precautions against Spontaneous Ignition of Coal. Precautions for Preventing Explosions of Fire-damp and Coal Dust. Employment of Electricity in Mining, particularly in Fiery Pits. Experiments on the Ignition of Fire-damp Mixtures and Clouds of Coal Dust by Electricity—**Indications of an Existing or Incipient Fire—Appliances for Working in Irrespirable Gases:** Respiratory Apparatus; Apparatus with Air Supply Pipes; Reservoir Apparatus; Oxygen Apparatus—**Extinguishing Pit Fires:** (a) Chemical Means; (b) Extinction with Water. Dragging down the Burning Masses and Packing with Clay; (c) Insulating the Seat of the Fire by Dams. Dam Building. Analyses of Fire Gases. Isolating the Seat of a Fire with Dams; Working in Irrespirable Gases ("Gas-diving"); Air-Lock Work. Complete Isolation of the Pit. Flooding a Burning Section isolated by means of Dams. Wooden Dams; Masonry Dams. Examples of Cylindrical and Dome-shaped Dams. Dam Doors: Flooding the Whole Pit—**Rescue Stations:** (a) Stations above Ground; (b) Underground Rescue Stations—**Spontaneous Ignition of Coal in Bulk—Index.**

VENTILATION IN MINES. By ROBERT WABNER, Mining Engineer. Translated from the German. Royal 8vo. Thirty Plates and Twenty-two Illustrations. 240 pp. Price 10s. 6d. net. (Post free, 11s. home; 11s. 3d. abroad.)

Contents.

The Causes of the Contamination of Pit Air—The Means of Preventing the Dangers resulting from the Contamination of Pit Air—Calculating the Volume of Ventilating Current necessary to free Pit Air from Contamination—Determination of the Resistance Opposed to the Passage of Air through the Pit—Laws of Resistance and Formulæ therefor—Fluctuations in the Temperament or Specific Resistance of a Pit—Means for Providing a Ventilating Current in the Pit—Mechanical Ventilation—Ventilators and Fans—Determining the Theoretical, Initial, and True (Effective) Depression of the Centrifugal Fan—New Types of Centrifugal Fan of Small Diameter and High Working Speed—Utilising the Ventilating Current to the utmost Advantage and distributing the same through the Workings—Artificially retarding the Ventilating Current—Ventilating Preliminary Workings—Blind Headings—Separate Ventilation—Supervision of Ventilation—INDEX.

HAULAGE AND WINDING APPLIANCES USED IN MINES. By CARL VOLK. Translated from the German. Royal 8vo. With Six Plates and 148 Illustrations. 150 pp. Price 8s. 6d. net. (Post free, 9s. home; 9s. 3d. abroad.)

Contents.

Haulage Appliances—Ropes—Haulage Tubs and Tracks—Cages and Winding Appliances—Winding Engines for Vertical Shafts—Winding without Ropes—Haulage in Levels and Inclines—The Working of Underground Engines—Machinery for Downhill Haulage.

Dental Metallurgy.

DENTAL METALLURGY: MANUAL FOR STUDENTS AND DENTISTS. By A. B. GRIFFITHS, Ph.D. Demy 8vo. Thirty-six Illustrations. 200 pp. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Introduction—Physical Properties of the Metals—Action of Certain Agents on Metals—Alloys—Action of Oral Bacteria on Alloys—Theory and Varieties of Blowpipes—Fluxes—Furnaces and Appliances—Heat and Temperature—Gold—Mercury—Silver—Iron—Copper—Zinc—Magnesium—Cadmium—Tin—Lead—Aluminium—Antimony—Bismuth—Palladium—Platinum—Iridium—Nickel—Practical Work—Weights and Measures.

Engineering, Smoke Prevention and Metallurgy.

THE PREVENTION OF SMOKE. Combined with the Economical Combustion of Fuel. By W. C. POPPLEWELL, M.Sc., A.M.Inst., C.E., Consulting Engineer. Forty-six Illustrations. 190 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. 3d. abroad.)

Contents.

Fuel and Combustion—Hand Firing in Boiler Furnaces—Stoking by Mechanical Means—Powdered Fuel—Gaseous Fuel—Efficiency and Smoke Tests of Boilers—Some Standard Smoke Trials—The Legal Aspect of the Smoke Question—The Best Means to be adopted for the Prevention of Smoke—Index.

GAS AND COAL DUST FIRING. A Critical Review of the Various Appliances Patented in Germany for this purpose since 1885. By ALBERT PÜTSCH. 130 pp. Demy 8vo. Translated from the German. With 103 Illustrations. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Generators—Generators Employing Steam—Stirring and Feed Regulating Appliances—Direct Generators—Burners—Regenerators and Recuperators—Glass Smelting Furnaces—Metallurgical Furnaces—Pottery Furnace—Coal Dust Firing—Index.

THE HARDENING AND TEMPERING OF STEEL IN THEORY AND PRACTICE. By FRIDOLIN REISER. Translated from the German of the Third Edition. Crown 8vo. 120 pp. Price 5s. net. (Post free, 5s. 3d. home; 5s. 4d. abroad.)

Contents.

Steel—Chemical and Physical Properties of Steel, and their Casual Connection—Classification of Steel according to Use—Testing the Quality of Steel—Steel-Hardening—Investigation of the Causes of Failure in Hardening—Regeneration of Steel Spoilt in the Furnace—Welding Steel—Index.

SIDEROLOGY: THE SCIENCE OF IRON (The Constitution of Iron Alloys and Slags). Translated from German of HANNS FREIHERR V. JÜPTNER. 350 pp. Demy 8vo. Eleven Plates and Ten Illustrations. Price 10s. 6d. net. (Post free, 11s. home; 11s. 6d. abroad.)

Contents.

The Theory of Solution.—Solutions—Molten Alloys—Varieties of Solutions—Osmotic Pressure—Relation between Osmotic Pressure and other Properties of Solutions—Osmotic Pressure and Molecular Weight of the Dissolved Substance—Solutions of Gases—Solid Solutions—Solubility—Diffusion—Electrical Conductivity—Constitution of Electrolytes and Metals—Thermal Expansion. **Micrography.**—Microstructure—The Micrographic Constituents of Iron—Relation between Micrographical Composition, Carbon-Content, and Thermal Treatment of Iron Alloys—The Microstructure of Slags. **Chemical Composition of the Alloys of Iron.**—Constituents of Iron Alloys—Carbon—Constituents of the Iron Alloys, Carbon—Opinions and Researches on Combined Carbon—Opinions and Researches on Combined Carbon—Applying the Curves of Solution deduced from the Curves of Recalescence to the Determination of the Chemical Composition of the Carbon present in Iron Alloys—The Constituents of Iron—Iron—The Constituents of Iron Alloys—Manganese—Remaining Constituents of Iron Alloys—A Silicon—Gases. **The Chemical Composition of Slag.**—Silicate Slags—Calculating the Composition of Silicate Slags—Phosphate Slags—Oxide Slags—Appendix—Index.

EVAPORATING, CONDENSING AND COOLING APPARATUS. Explanations, Formulæ and Tables for Use in Practice. By E. HAUSBRAND, Engineer. Translated by A. C. WRIGHT, M.A. (Oxon.), B.Sc. (Lond.). With Twenty-one Illustrations and Seventy-six Tables. 400 pp. Demy 8vo. Price 10s. 6d. net. (Post free, 11s. home; 11s. 6d. abroad.)

Contents of "Evaporating, Condensing and Cooling Apparatus".

ReCoefficient of Transmission of Heat, k , and the Mean Temperature Difference, θ_m —Parallel and Opposite Currents—Apparatus for Heating with Direct Fire—The Injection of Saturated Steam—Superheated Steam—Evaporation by Means of Hot Liquids—The Transference of Heat in General, and Transference by means of Saturated Steam in Particular—The Transference of Heat from Saturated Steam in Pipes (Coils) and Double Bottoms—Evaporation in a Vacuum—The Multiple-effect Evaporator—Multiple-effect Evaporators from which Extra Steam is Taken—The Weight of Water which must be Evaporated from 100 Kilos. of Liquor in order its Original Percentage of Dry Materials from 1-25 per cent. up to 20-70 per cent.—The Relative Proportion of the Heating Surfaces in the Elements of the Multiple Evaporator and their Actual Dimensions—The Pressure Exerted by Currents of Steam and Gas upon Floating Drops of Water—The Motion of Floating Drops of Water upon which Press Currents of Steam—The Splashing of Evaporating Liquids—The Diameter of Pipes for Steam, Alcohol, Vapour and Air—The Diameter of Water Pipes—The Loss of Heat from Apparatus and Pipes to the Surrounding Air, and Means for Preventing the Loss—Condensers—Heating Liquids by Means of Steam—The Cooling of Liquids—The Volumes to be Exhausted from Condensers by the Air-pumps—A Few Remarks on Air-pumps and the Vacua they Produce—The Volumetric Efficiency of Air-pumps—The Volumes of Air which must be Exhausted from a Vessel in order to Reduce its Original Pressure to a Certain Lower Pressure—Index.

Sanitary Plumbing, Metal Work, etc., etc.

EXTERNAL PLUMBING WORK. A Treatise on Lead Work for Roofs. By JOHN W. HART, R.P.C. 180 Illustrations. 272 pp. Demy 8vo. Second Edition Revised. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Cast Sheet Lead—Milled Sheet Lead—Roof Cesspools—Socket Pipes—Drips—Gutters—Gutters (continued)—Breaks—Circular Breaks—Flats—Flats (continued)—Rolls on Flats—Roll Ends—Roll Intersections—Seam Rolls—Seam Rolls (continued)—Tack Fixings—Step Flashings—Step Flashings (continued)—Secret Gutters—Soakers—Hip and Valley Soakers—Dormer Windows—Dormer Windows (continued)—Dormer Tops—Internal Dormers—Skylights—Hips and Ridging—Hips and Ridging (continued)—Fixings for Hips and Ridging—Ornamental Ridging—Ornamental Curb Rolls—Curb Rolls—Cornices—Towers and Finials—Towers and Finials (continued)—Towers and Finials (continued)—Domes—Domes (continued)—Ornamental Lead Work—Rain Water Heads—Rain Water Heads (continued)—Rain Water Heads (continued).

HINTS TO PLUMBERS ON JOINT WIPING, PIPE BENDING AND LEAD BURNING. Third Edition, Revised and Corrected. By JOHN W. HART, R.P.C. 184 Illustrations. 313 pp. Demy 8vo. Price 7s. 6d. net. (Post free, 8s. home; 8s. 6d. abroad.)

Contents.

Pipe Bending—Pipe Bending (continued)—Pipe Bending (continued)—Square Pipe Bendings—Half-circular Elbows—Curved Bends on Square Pipe—Bossed Bends—Curved Plinth Bends—Rain-water Shoes on Square Pipe—Curved and Angle Bends—Square Pipe Fixings—Joint-wiping—Substitutes for Wiped Joints—Preparing Wiped Joints—Joint Fixings—Plumbing Irons—Joint Fixings—Use of "Touch" in Soldering—Underhand Joints—Blown and Copper Bit Joints—Branch Joints—Branch Joints (continued)—Block Joints—Block Joints (continued)—Block Fixings—Astragal Joints—Pipe Fixings—Large Branch Joints—Large Underhand Joints—Solders—Autogenous Soldering or Lead Burning—Index.

SANITARY PLUMBING AND DRAINAGE. By JOHN W. HART. Demy 8vo. With 208 Illustrations. 250 pp. 1904. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Sanitary Surveys—Drain Testing—Drain Testing with Smoke—Testing Drains with Water—Drain Plugs for Testing—Sanitary Defects—Closets—Baths and Lavatories—House Drains—Manholes—Iron Soil Pipes—Lead Soil Pipes—Ventilating Pipes—Water-closets—Flushing Cisterns—Baths—Bath Fittings—Lavatories—Lavatory Fittings—Sinks—Waste Pipes—Water Supply—Ball Valves—Town House Sanitary Arrangements—Drainage—Joining Pipes—Accessible Drains—Iron Drains—Iron Junctions—Index.

THE PRINCIPLES AND PRACTICE OF DIPPING, BURNISHING, LACQUERING AND BRONZING BRASS WARE. By W. NORMAN BROWN. 35 pp. Crown 8vo. Price 2s. net. (Post free, 2s. 3d. home and abroad.)

A HANDBOOK ON JAPANING AND ENAMELLING FOR CYCLES, BEDSTEADS, TINWARE, ETC. By WILLIAM NORMAN BROWN. 52 pp. and Illustrations. Crown 8vo. Price 2s. net. (Post free, 2s. 3d. home and abroad.)

THE PRINCIPLES OF HOT WATER SUPPLY. By JOHN W. HART, R.P.C. With 129 Illustrations. 177 pp., demy 8vo. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. abroad.)

Contents.

Water Circulation—The Tank System—Pipes and Joints—The Cylinder System—Boilers for the Cylinder System—The Cylinder System—The Combined Tank and Cylinder System—Combined Independent and Kitchen Boiler—Combined Cylinder and Tank System with Duplicate Boilers—Indirect Heating and Boiler Explosions—Pipe Boilers—Safety Valves—Safety Valves—The American System—Heating Water by Steam—Steam Kettles and Jets—Heating Power of Steam—Covering for Hot Water Pipes—Index.

House Decorating and Painting.

THREE HUNDRED SHADES FOR DECORATORS AND HOW TO MIX THEM. By A. DESAINT. Quarto. The book will consist of a wide range of shades and tints suitable for decorators carefully numbered and mounted for easy reference, with full particulars as to the composition of each shade.

[In the press.]

HOUSE DECORATING AND PAINTING. By W. NORMAN BROWN. Eighty-eight Illustrations. 150 pp. Crown 8vo. Price 3s. 6d. net. (Post free, 3s. 9d. home and abroad.)

A HISTORY OF DECORATIVE ART. By W. NORMAN BROWN. Thirty-nine Illustrations. 96 pp. Crown 8vo. Price 2s. 6d. net. (Post free, 2s. 9d. home and abroad.)

WORKSHOP WRINKLES for Decorators, Painters, Paper-hangers and Others. By W. N. BROWN. Crown 8vo. 128 pp. Second Edition. Price 2s. 6d. net. (Post free, 2s. 9d. home; 2s. 10d. abroad.)

Brewing and Botanical.

HOPS IN THEIR BOTANICAL, AGRICULTURAL AND TECHNICAL ASPECT, AND AS AN ARTICLE OF COMMERCE. By EMMANUEL GROSS, Professor at the Higher Agricultural College, Tetschen-Liebwerd. Translated from the German. Seventy-eight Illustrations. 340 pp. Demy 8vo. Price 12s. 6d. net. (Post free, 13s. home; 13s. 6d. abroad.)

Contents.

HISTORY OF THE HOP—THE HOP PLANT—Introductory—The Roots—The Stem—and Leaves—Inflorescence and Flower: Inflorescence and Flower of the Male Hop; Inflorescence and Flower of the Female Hop—The Fruit and its Glandular Structure: The

Fruit and Seed—Propagation and Selection of the Hop—Varieties of the Hop: (a) Red Hops; (b) Green Hops; (c) Pale Green Hops—Classification according to the Period of Ripening: Early August Hops; Medium Early Hops; Late Hops—Injuries to Growth—Leaves Turning Yellow, Summer or Sunbrand, Cones Dropping Off, Honey Dew, Damage from Wind, Hail and Rain; Vegetable Enemies of the Hop: Animal Enemies of the Hop—Beneficial Insects on Hops—**CULTIVATION**—The Requirements of the Hop in Respect of Climate, Soil and Situation: Climate; Soil: Situation—Selection of Variety and Cuttings—Planting a Hop Garden: Drainage; Preparing the Ground; Marking-out for Planting; Planting; Cultivation and Cropping of the Hop Garden in the First Year—Work to be Performed Annually in the Hop Garden: Working the Ground; Cutting; The Non-cutting System; The Proper Performance of the Operation of Cutting; Method of Cutting: Close Cutting, Ordinary Cutting, The Long Cut, The Topping Cut; Proper Season for Cutting: Autumn Cutting, Spring Cutting; Manuring; Training the Hop Plant: Poled Gardens, Frame Training; Principal Types of Frames; Pruning, Cropping, Topping, and Leaf Stripping the Hop Plant; Picking, Drying and Bagging—Principal and Subsidiary Utilisation of Hops and Hop Gardens—Life of a Hop Garden; Subsequent Cropping—Cost of Production, Yield and Selling Prices.

Preservation and Storage—Physical and Chemical Structure of the Hop Cone—Judging the Value of Hops.

Statistics of Production—The Hop Trade—Index.

Timber and Wood Waste.

TIMBER: A Comprehensive Study of Wood in all its Aspects (Commercial and Botanical), showing the Different Applications and Uses of Timber in Various Trades, etc. Translated from the French of PAUL CHARPENTIER. Royal 8vo. 437 pp. 178 Illustrations. Price 12s. 6d. net. (Post free, 13s. home; 14s. abroad.)

Contents.

Physical and Chemical Properties of Timber—Composition of the Vegetable Bodies—Chief Elements—M. Fremy's Researches—Elementary Organs of Plants and especially of Forests—Different Parts of Wood Anatomically and Chemically Considered—General Properties of Wood—**Description of the Different Kinds of Wood**—Principal Essences with Caducous Leaves—Coniferous Resinous Trees—**Division of the Useful Varieties of Timber in the Different Countries of the Globe**—European Timber—African Timber—Asiatic Timber—American Timber—Timber of Oceania—**Forests**—General Notes as to Forests; their Influence—Opinions as to Sylviculture—Improvement of Forests—Unwooding and Rewooding—Preservation of Forests—Exploitation of Forests—Damage caused to Forests—Different Alterations—**The Preservation of Timber**—Generalities—Causes and Progress of Deterioration—History of Different Proposed Processes—Dessication—Superficial Carbonisation of Timber—Processes by Immersion—Generalities as to Antiseptics Employed—Injection Processes in Closed Vessels—The Boucherie System, Based upon the Displacement of the Sap—Processes for Making Timber Uninflamable—**Applications of Timber**—Generalities—Working Timber—Paving—Timber for Mines—Railway Traverses—Accessory Products—Gums—Works of M. Fremy—Resins—Barks—Tan—Application of Cork—The Application of Wood to Art and Dyeing—Different Applications of Wood—Hard Wood—Distillation of Wood—Pyroligneous Acid—Oil of Wood—Distillation of Resins—Index.

THE UTILISATION OF WOOD WASTE. Translated from the German of ERNST HUBBARD. Crown 8vo. 192 pp. Fifty Illustrations. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

General Remarks on the Utilisation of Sawdust—Employment of Sawdust as Fuel, with and without Simultaneous Recovery of Charcoal and the Products of Distillation—Manufacture of Oxalic Acid from Sawdust—Process with Soda Lye; Thorn's Process: Bohlig's Process—Manufacture of Spirit (Ethyl Alcohol) from Wood Waste—Patent Dyes (Organic Sulphides, Sulphur Dyes, or Mercapto Dyes)—Artificial Wood and Plastic Compositions from Sawdust—Production of Artificial Wood Compositions for Moulded Decorations—Employment of Sawdust for Blasting Powders and Gunpowders—Employment of Sawdust for Briquettes—Employment of Sawdust in the Ceramic Industry and as an Addition to Mortar—Manufacture of Paper Pulp from Wood—Casks—Various Applications of Sawdust and Wood Refuse—Calcium Carbide—Manure—Wood Mosaic Plaques—Bottle Stoppers—Parquetry—Fire-lighters—Carborundum—The Production of Wood Wool—Bark—Index.

Building and Architecture.

THE PREVENTION OF DAMPNESS IN BUILDINGS;

with Remarks on the Causes, Nature and Effects of Saline, Efflorescences and Dry-rot, for Architects, Builders, Overseers, Plasterers, Painters and House Owners. By ADOLF WILHELM KEIM. Translated from the German of the second revised Edition by M. J. SALTER, F.I.C., F.C.S. Eight Coloured Plates and Thirteen Illustrations. Crown 8vo. 115 pp. Price 5s. net. (Post free, 5s. 3d. home; 5s. 4d. abroad.)

Contents.

The Various Causes of Dampness and Decay of the Masonry of Buildings, and the Structural and Hygienic Evils of the Same—Precautionary Measures during Building against Dampness and Efflorescence—Methods of Remedying Dampness and Efflorescences in the Walls of Old Buildings—The Artificial Drying of New Houses, as well as Old Damp Dwellings, and the Theory of the Hardening of Mortar—New, Certain and Permanently Efficient Methods for Drying Old Damp Walls and Dwellings—The Cause and Origin of Dry-rot: its Injurious Effect on Health, its Destructive Action on Buildings, and its Successful Repression—Methods of Preventing Dry-rot to be Adopted During Construction—Old Methods of Preventing Dry-rot—Recent and More Efficient Remedies for Dry-rot—Index.

HANDBOOK OF TECHNICAL TERMS USED IN ARCHITECTURE AND BUILDING, AND THEIR ALLIED TRADES AND SUBJECTS. By AUGUSTINE C. PASSMORE.

Demy 8vo. 380 pp. Price 7s. 6d. net. (Post free, 8s. home; 8s. 6d. abroad.)

Foods and Sweetmeats.

THE MANUFACTURE OF PRESERVED FOODS AND SWEETMEATS. By A. HAUSNER. With Twenty-eight

Illustrations. Translated from the German of the third enlarged Edition. Crown 8vo. 225 pp. Price 7s. 6d. net. (Post free, 7s. 9d. home; 7s. 10d. abroad.)

Contents.

The Manufacture of Conserves—Introduction—The Causes of the Putrefaction of Food—The Chemical Composition of Foods—The Products of Decomposition—The Causes of Fermentation and Putrefaction—Preservative Bodies—The Various Methods of Preserving Food—The Preservation of Animal Food—Preserving Meat by Means of Ice—The Preservation of Meat by Charcoal—Preservation of Meat by Drying—The Preservation of Meat by the Exclusion of Air—The Appert Method—Preserving Flesh by Smoking—Quick Smoking—Preserving Meat with Salt—Quick Salting by Air Pressure—Quick Salting by Liquid Pressure—Gamgee's Method of Preserving Meat—The Preservation of Eggs—Preservation of White and Yolk of Egg—Milk Preservation—Condensed Milk—The Preservation of Fat—Manufacture of Soup Tablets—Meat Biscuits—Extract of Beef—The Preservation of Vegetable Foods in General—Compressing Vegetables—Preservation of Vegetables by Appert's Method—The Preservation of Fruit—Preservation of Fruit by Storage—The Preservation of Fruit by Drying—Drying Fruit by Artificial Heat—Roasting Fruit—The Preservation of Fruit with Sugar—Boiled Preserved Fruit—The Preservation of Fruit in Spirit, Acetic Acid or Glycerine—Preservation of Fruit without Boiling—Jam Manufacture—The Manufacture of Fruit Jellies—The Making of Gelatine Jellies—The Manufacture of "Sulzen"—The Preservation of Fermented Beverages—The Manufacture of Candies—Introduction—The Manufacture of Candied Fruit—The Manufacture of Boiled Sugar and Caramel—The Candying of Fruit—Caramelised Fruit—The Manufacture of Sugar Sticks, or Barley Sugar—Bonbon Making—Fruit Drops—The Manufacture of Dragées—The Machinery and Appliances used in Candy Manufacture—Dyeing Candies and Bonbons—Essential Oils used in Candy Making—Fruit Essences—The Manufacture of Filled Bonbons, Liqueur Bonbons and Stamped Lozenges—Recipes for Jams and Jellies—Recipes for Bonbon Making—Dragées—Appendix—Index.

Dyeing Fancy Goods.

THE ART OF DYEING AND STAINING MARBLE, ARTIFICIAL STONE, BONE, HORN, IVORY AND WOOD, AND OF IMITATING ALL SORTS OF WOOD. A Practical Handbook for the Use of Joiners, Turners, Manufacturers of Fancy Goods, Stick and Umbrella Makers, Comb Makers, etc. Translated from the German of D. H. SOXHLET, Technical Chemist. Crown 8vo. 168 pp. Price 5s. net. (Post free, 5s. 3d. home; 5s. 4d. abroad.)

Contents.

Mordants and Stains—Natural Dyes—Artificial Pigments—Coal Tar Dyes—Staining Marble and Artificial Stone—Dyeing, Bleaching and Imitation of Bone, Horn and Ivory—Imitation of Tortoiseshell for Combs: Yellows, Dyeing Nuts—Ivory—Wood Dyeing—Imitation of Mahogany: Dark Walnut, Oak, Birch-Bark, Elder-Marquetry, Walnut, Walnut-Marquetry, Mahogany, Spanish Mahogany, Palisander and Rose Wood, Tortoiseshell, Oak, Ebony, Pear Tree—Black Dyeing Processes with Penetrating Colours—Varnishes and Polishes: English Furniture Polish, Vienna Furniture Polish, Amber Varnish, Copal Varnish, Composition for Preserving Furniture—Index.

Celluloid.

CELLULOID. The Raw Material, Manufacture and Uses. By Dr. FR. BÖCKMANN. 49 Illus. Crown 8vo. *[In the Press.]*

Lithography, Printing and Engraving.

PRACTICAL LITHOGRAPHY. By ALFRED SEYMOUR. Demy 8vo. With Frontispiece and 33 Illus. 120 pp. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

Stones—Transfer Inks—Transfer Papers—Transfer Printing—Litho Press—Press Work—Machine Printing—Colour Printing—Substitutes for Lithographic Stones—Tin Plate Printing and Decoration—Photo-Lithography.

PRINTERS' AND STATIONERS' READY RECKONER AND COMPENDIUM. Compiled by VICTOR GRAHAM. Crown 8vo. 112 pp. 1904. Price 3s. 6d. net. (Post free, 3s. 9d. home; 3s. 10d. abroad.)

Contents.

Price of Paper per Sheet, Quire, Ream and Lb.—Cost of 100 to 1000 Sheets at various Sizes and Prices per Ream—Cost of Cards—Quantity Table—Sizes and Weights of Paper, Cards, etc.—Notes on Account Books—Discount Tables—Sizes of spaces—Leads to a lb.—Dictionary—Measure for Bookwork—Correcting Proofs, etc.

ENGRAVING FOR ILLUSTRATION. HISTORICAL AND PRACTICAL NOTES. By J. KIRKBRIDE. 72 pp. Two Plates and 6 Illustrations. Crown 8vo. Price 2s. 6d. net. (Post free, 2s. 9d. home; 2s. 10d. abroad.)

Contents.

Its Inception—Wood Engraving—Metal Engraving—Engraving in England—Etching—Mezzotint—Photo-Process Engraving—The Engraver's Task—Appreciative Criticism—Index.

Bookbinding.

PRACTICAL BOOKBINDING. By PAUL ADAM. Translated from the German. Crown 8vo. 180 pp. 127 Illustrations. Price 5s. net. (Post free, 5s. 4d. home; 5s. 6d. abroad.)

Contents.

Materials for Sewing and Pasting—Materials for Covering the Book—Materials for Decorating and Finishing—Tools—General Preparatory Work—Sewing—Forwarding.

Cutting, Rounding and Backing—Forwarding, Decoration of Edges and Headbanding—Boarding—Preparing the Cover—Work with the Blocking Press—Treatment of Sewn Books, Fastening in Covers, and Finishing Off—Handtooling and Other Decoration—Account Books—School Books, Mounting Maps, Drawings, etc.—Index.

Sugar Refining.

THE TECHNOLOGY OF SUGAR: Practical Treatise on the Modern Methods of Manufacture of Sugar from the Sugar Cane and Sugar Beet. By JOHN GEDDES MCINTOSH. Second Revised and Enlarged Edition. Demy 8vo. Fully Illustrated. 436 pp. Seventy-six Tables. 1906. Price 10s. 6d. net. (Post free, 11s. home; 11s. 6d. abroad.)

Contents.

Chemistry of Sucrose, Lactose, Maltose, Glucose, Invert Sugar, etc.—Purchase and Analysis of Beets—Treatment of Beets—Diffusion—Filtration—Concentration—Evaporation—**Sugar Cane:** Cultivation—Milling—Diffusion—Sugar Refining—Analysis of Raw Sugars—Chemistry of Molasses, etc.

(See "*Evaporating, Condensing, etc., Apparatus*," p. 26.)

Bibliography.

CLASSIFIED GUIDE TO TECHNICAL AND COMMERCIAL BOOKS. Compiled by EDGAR GREENWOOD. Demy 8vo. 224 pp. 1904. Being a Subject-list of the Principal British and American Books in print; giving Title, Author, Size, Date, Publisher and Price. Price 7s. 6d. net. (Post free, 7s. 10d. home; 8s. 3d. abroad.)

THE TECHNICAL BOOKS in this Catalogue can be obtained through all Booksellers, or post free direct from the Publishers by remitting the amount given in brackets.

Full Particulars of Contents of any of the above books will be sent on application.

Books in the Press.—The Publishers will send Contents and prices of books in the press as soon as ready to any one sending their address.

Technical Books upon **all Subjects** can be obtained through SCOTT, GREENWOOD & SON, if requirements are fully stated.

SCOTT, GREENWOOD & SON,

Technical Book Publishers,

8 BROADWAY, LUDGATE HILL,

LONDON, E.C.

Telegraphic Address, "Printeries, London".

[April, 1907.]

STOKE-ON-TRENT
PUBLIC LIBRARIES

HORACE BARKS
Reference Library

.....

.....

117 OCT 1911

